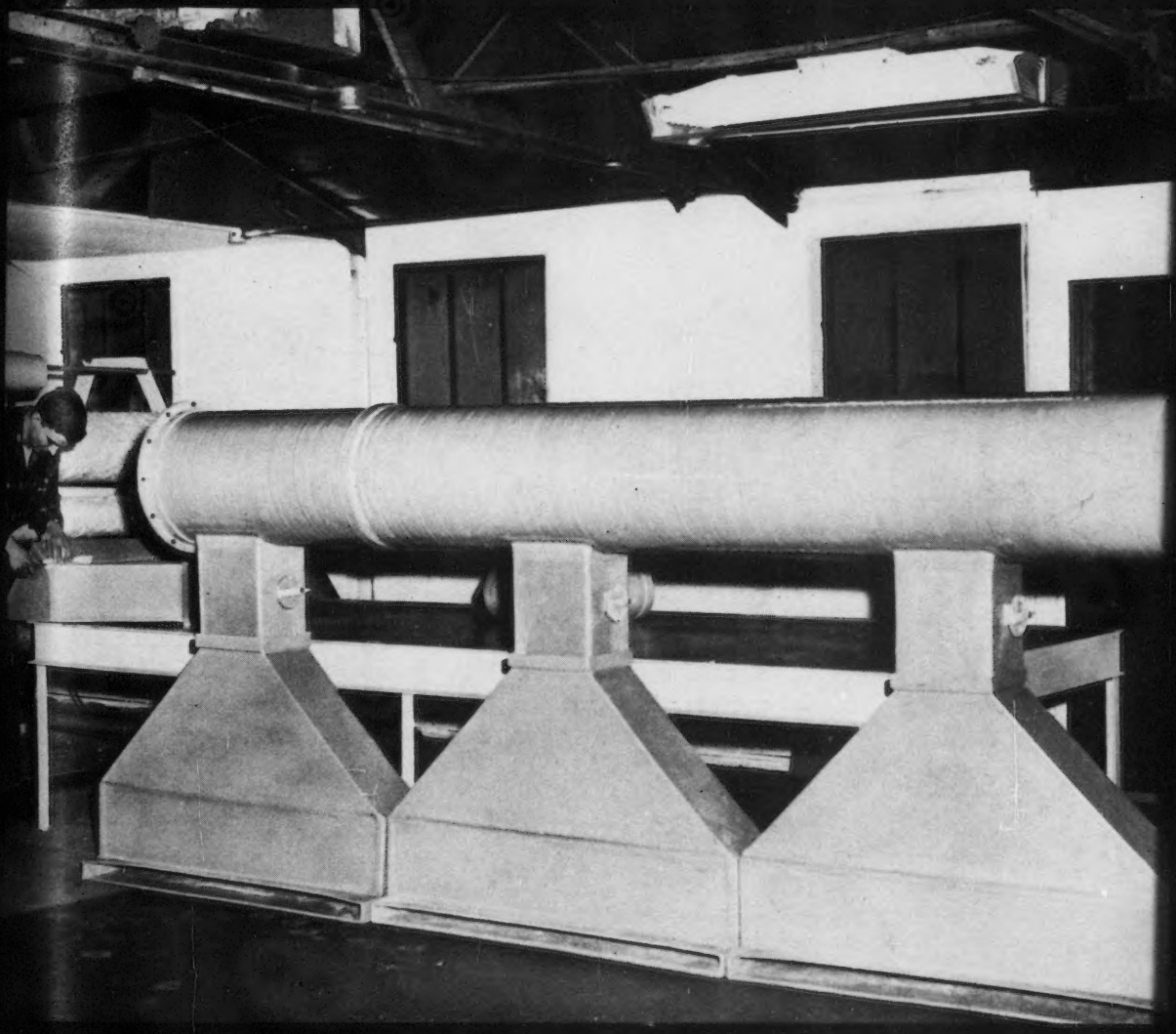
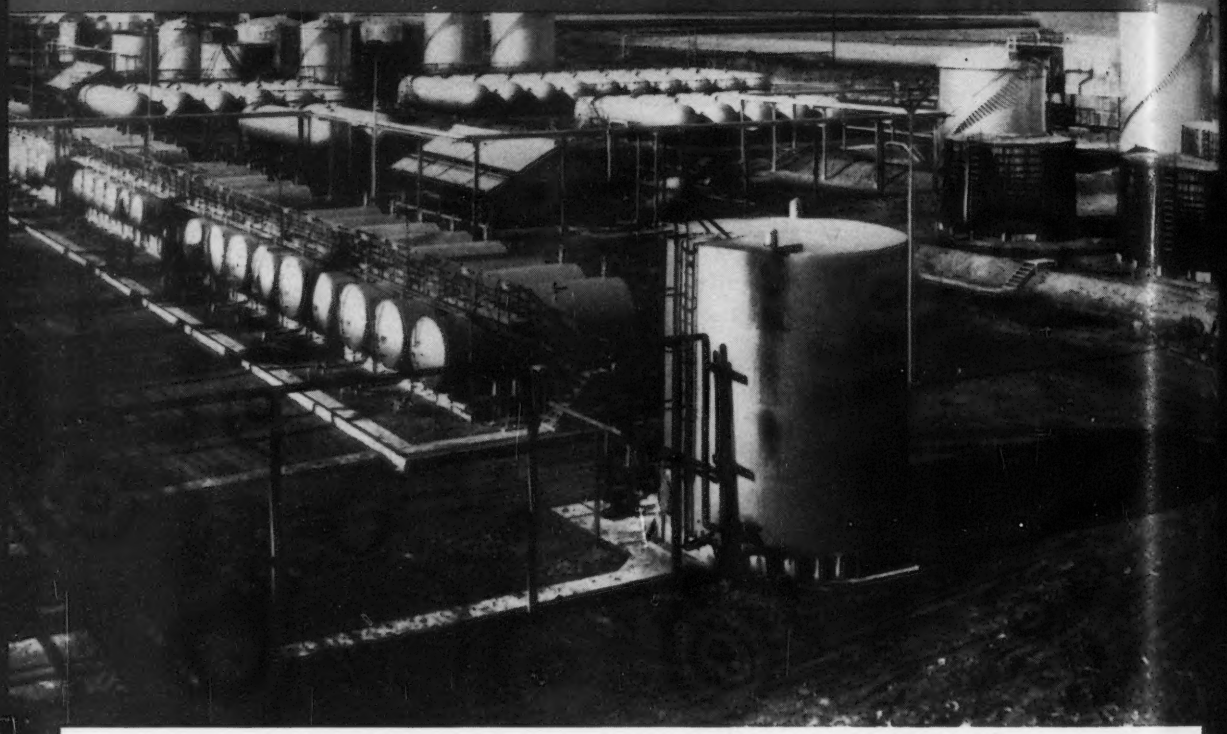
Corrosion



There's more to CORROSION than meets the eye



Sometimes VISIBLE... Often HIDDEN... Corrosion Strikes in Every Plant

This year, American Industry will pay more than $6,000,000,000 for losses created by corrosion... *yet much of this corrosion may never be discovered* until it's too late to protect—and time to pay!

Corrosion is readily detected when it appears as rust layers or failing paint on exposed surfaces. But, by far, the major costs of corrosion come from hidden areas—where only minute inspections and constant care can prevent costly failures.

YOU LOSE IN A "WAITING GAME"

Don't wait for rust or other visible signs to appear. Visible or hidden, corrosion will destroy costly equipment... halt production... cause unnecessary maintenance shutdowns... and contaminate valuable products. Thus, corrosion dips deep into your profits as it creates needless losses totaling thousands of dollars.

YOU CAN PREVENT NEEDLESS WASTE

Check your plant for corrosion's presence. Double-check areas that are vulnerable to *hidden corrosion.* If you would like help, an AMERCOAT Field Engineer will gladly assist you in making a thorough analysis. There is no obligation.

What is AMERCOAT?

AMERCOAT is a method of corrosion control. Not just a single product, but a complete LINE of coatings, individually formulated to solve or control specific industrial corrosion problems.

FOLLOW THE LINE OF *more* RESISTANCE... PROTECT WITH *Amercoat!*

AMERCOAT CORPORATION

4809 FIRESTONE BLVD., SOUTH GATE, CALIFORNIA

CHICAGO, ILL. NEWARK, N. J. JACKSONVILLE, FLA. DALLAS, TEX.

The world's most valuable piece of *REAL ESTATE!*

It was from this one soil sample . . . out of tens of thousands from all over the world . . . that a team of scientists in 1950 first isolated the mold growth that produces terramycin. Today, impressive quantities of terramycin produced from this original mold are bringing under control some eighty diseases, including certain serious virus infections.

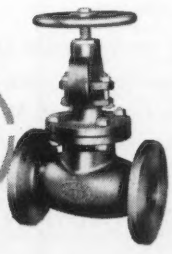
A vast network of pipes and valves regulate the proportion and control the flow of the liquid media in which the antibiotic mold is grown. To safeguard the purity of this vital liquid from harmful contamination ALOYCO Stainless Steel Valves are used in the plant producing terramycin.

Most of the manufacturers of the new wonder drugs such as terramycin, penicillin, chloromycetin, streptomycin, neomycin, as well as other leaders in the chemical industries, have come to use many different types of ALOYCO corrosion-resistant valves. Our long and extremely diversified experience in the field together with our pre-testing of alloys under actual line conditions enable us to supply valves of the proper alloy and best design for every corrosive service.

If corrosives play a part in your business, it will pay you to bring your problems of corrosion, contamination, discoloration, or temperature extremes to the *Aloyco Corrosion Engineering Service*. Here the world's largest specialists in corrosion-resistant valves will help you determine which valves best meet your requirements.

ALOYCO valves go hand-in-hand with chemical progress. 3.6

Longer Lasting
ALOYCO VALVES
1st in Corrosive Service

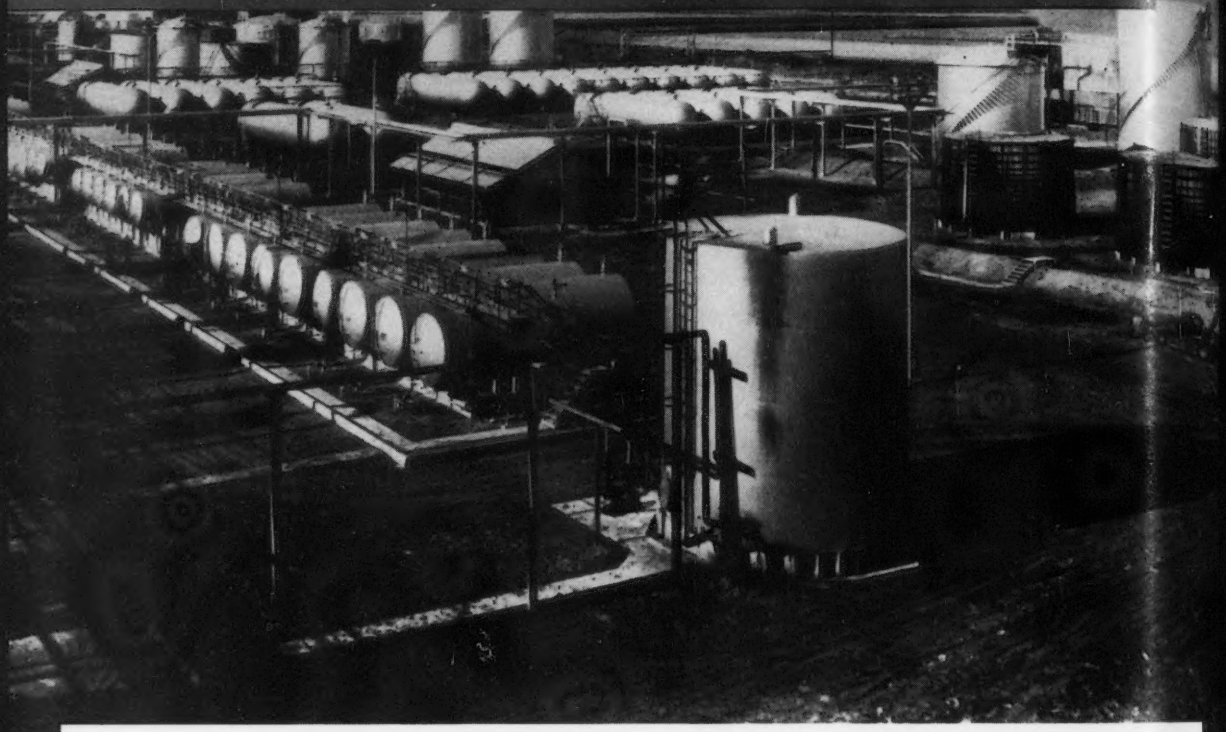


ALLOY STEEL PRODUCTS CO., INC.
1323 West Elizabeth Avenue, Linden, N. J.
Plants: Linden, N. J.; Bloomfield, N. J.; Elizabeth, N. J.

DISTRICT OFFICES

NEW YORK 1, N. Y.
350 Fifth Avenue
WILMINGTON, DEL.
226 West Ninth St.
PITTSBURGH 22, PA.
318 Investment Bldg.
ATLANTA, GEORGIA
333 Candler Bldg.
ST. LOUIS, MISSOURI
1221 Locust St.
CHICAGO 4, ILLINOIS
332 So. Michigan Ave.
HOUSTON 6, TEXAS
K. E. Luger Co.
2716 Danville St.
SAN FRANCISCO, CALIF.
24 California St.
LOS ANGELES 22, CALIF.
5442 Jillson St.

There's more to CORROSION than meets the eye



Sometimes VISIBLE... Often HIDDEN... Corrosion Strikes in Every Plant

This year, American Industry will pay more than $6,000,000,000 for losses created by corrosion... *yet much of this corrosion may never be discovered* until it's too late to protect—and time to pay!

Corrosion is readily detected when it appears as rust layers or failing paint on exposed surfaces. But, by far, the major costs of corrosion come from hidden areas—where only minute inspections and constant care can prevent costly failures.

YOU LOSE IN A "WAITING GAME"

Don't wait for rust or other visible signs to appear. Visible or hidden, corrosion will destroy costly equipment... halt production... cause unnecessary maintenance shutdowns... and contaminate valuable products. Thus, corrosion dips deep into your profits as it creates needless losses totaling thousands of dollars.

YOU CAN PREVENT NEEDLESS WASTE

Check your plant for corrosion's presence. Double-check areas that are vulnerable to *hidden corrosion.* If you would like help, an AMERCOAT Field Engineer will gladly assist you in making a thorough analysis. There is no obligation.

What is AMERCOAT?

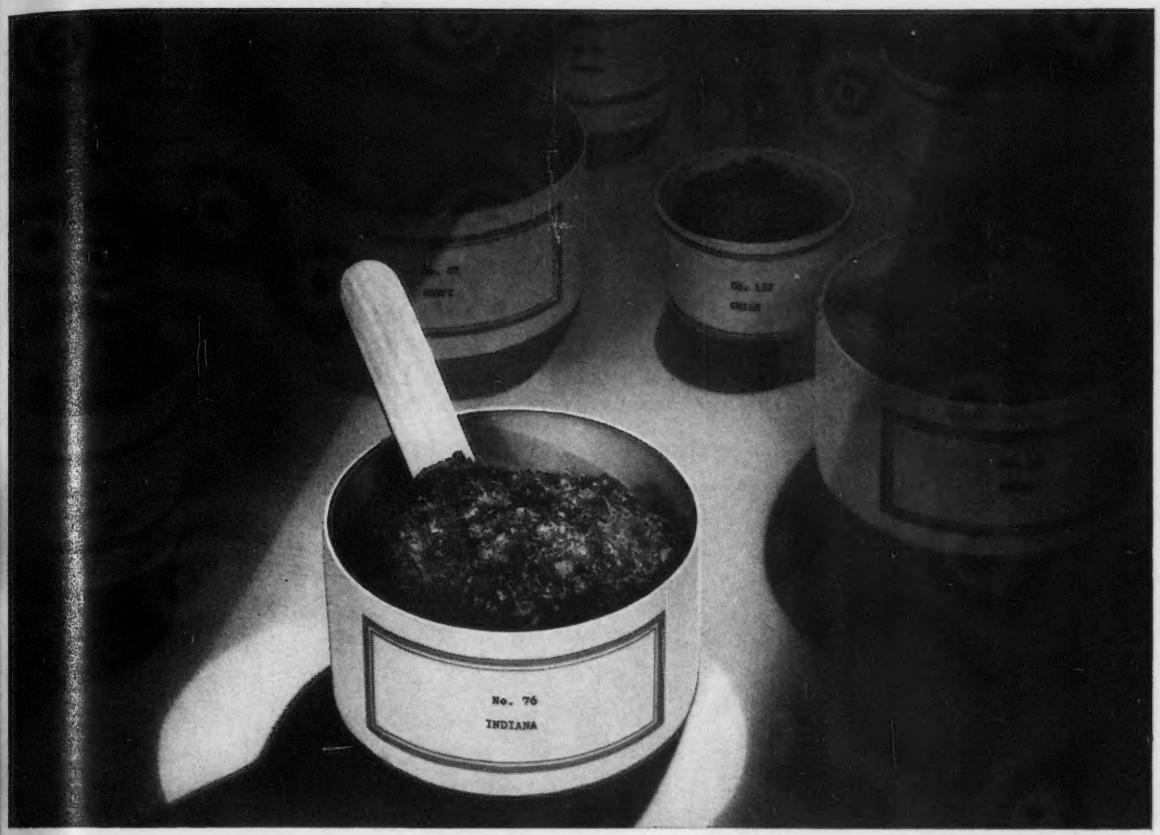
AMERCOAT is a method of corrosion control. Not just a single product, but a complete LINE of coatings, individually formulated to solve or control specific industrial corrosion problems.

FOLLOW THE LINE OF MOST RESISTANCE... PROTECT WITH Amercoat!

AMERCOAT CORPORATION

4809 FIRESTONE BLVD., SOUTH GATE, CALIFORNIA

CHICAGO, ILL. NEWARK, N. J. JACKSONVILLE, FLA. DALLAS, TEX.



The world's most valuable piece of *REAL ESTATE!*

It was from this one soil sample . . . out of tens of thousands from all over the world . . . that a team of scientists in 1950 first isolated the mold growth that produces terramycin. Today, impressive quantities of terramycin produced from this original mold are bringing under control some eighty diseases, including certain serious virus infections.

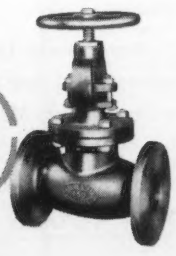
A vast network of pipes and valves regulate the proportion and control the flow of the liquid media in which the antibiotic mold is grown. To safeguard the purity of this vital liquid from harmful contamination ALOYCO Stainless Steel Valves are used in the plant producing terramycin.

Most of the manufacturers of the new wonder drugs such as terramycin, penicillin, chloromycetin, streptomycin, neomycin, as well as other leaders in the chemical industries, have come to use many different types of ALOYCO corrosion-resistant valves. Our long and extremely diversified experience in the field together with our pre-testing of alloys under actual line conditions enable us to supply valves of the proper alloy and best design for every corrosive service.

If corrosives play a part in your business, it will pay you to bring your problems of corrosion, contamination, discoloration, or temperature extremes to the *Aloyco Corrosion Engineering Service*. Here the world's largest specialists in corrosion-resistant valves will help you determine which valves best meet your requirements.

ALOYCO valves go hand-in-hand with chemical progress. 3.6

Longer Lasting
ALOYCO VALVES
1st in Corrosive Service



ALLOY STEEL PRODUCTS CO., INC.
1323 West Elizabeth Avenue, Linden, N. J.
Plants: Linden, N. J.; Bloomfield, N. J.; Elizabeth, N. J.

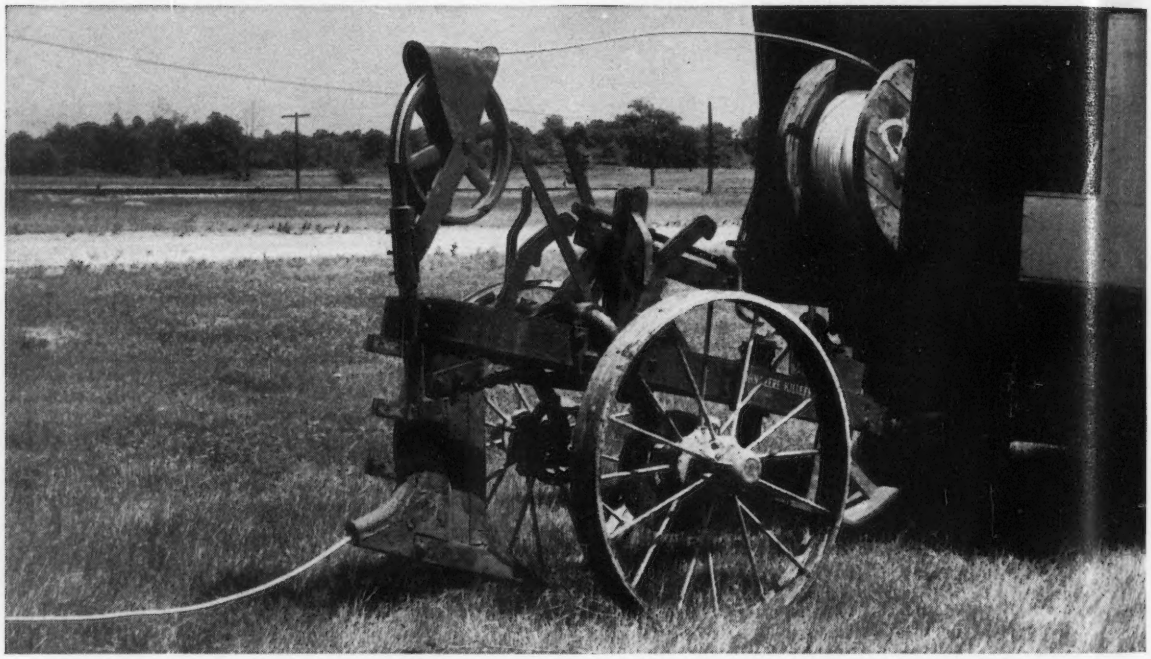
DISTRICT OFFICES

NEW YORK 1, N. Y.
350 Fifth Avenue
WILMINGTON, DEL.
226 West Ninth St.
PITTSBURGH 22, PA.
318 Investment Bldg.
ATLANTA, GEORGIA
333 Candler Bldg.
ST. LOUIS, MISSOURI
1221 Locust St.
CHICAGO 4, ILLINOIS
332 So. Michigan Ave.
HOUSTON 6, TEXAS
K. E. Luger Co.
2716 Danville St.
SAN FRANCISCO, CALIF.
24 California St.
LOS ANGELES 22, CALIF.
5442 Jillson St.

DOW

CUT THE COST OF PIPELINE PROTECTION WITH GALVO-LINE

Dow's Magnesium ribbon anode saves time and labor in installation



Galvo-Line is installed by wire-laying plow drawn by truck or tractor.

Has the high cost of anode installation discouraged you from using this most efficient method of pipeline protection? Then investigate Galvo-Line®, Dow's flexible cored, magnesium ribbon anode.

Time and labor are the big elements of cost in any anode installation. By providing a simplified method, these factors can be cut to the bone with Galvo-Line.

Up to *five miles of pipeline per day* can be protected by plowing in Galvo-Line. The installation is also simplified by the fact that the number of connections to the pipeline can be considerably reduced. Intervals of 500 to 1000 feet are generally adequate.

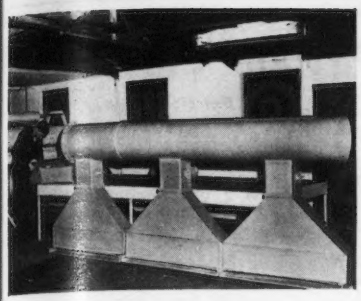
Galvo-Line cuts costs another way, too. It provides from three to seven times as much current per pound of magnesium installed as conventional magnesium anodes. More uniform distribution and efficient utilization of current make Galvo-Line both economical and dependable for pipeline protection.

When you plan your next protection program, figure it *two ways* . . . one with Galvo-Line. Let the facts prove themselves.

Call your nearest Dow office or Dow distributor for complete data. THE DOW CHEMICAL COMPANY, *Magnesium Department*, Midland, Michigan.

you can depend on DOW MAGNESIUM ANODES

DOW



THIS MONTH'S COVER—These exhaust hoods and duct with dampers will remove acid fumes from industrial electroplating tanks. The assembly is made of standard shapes of Rigidon Plastic, a glass laminate, by Heil Process Equipment. Corp., Cleveland. Besides high resistance to corrosive vapors the assembly is light compared to an equivalent metal structure of the same character and has ample strength.

☆

EDITORIAL STAFF

IVY M. PARKER—*Editor*

EDITORIAL REVIEW COMMITTEE

THOMAS P. MAY, *Chairman*
GEORGE DIEHLMAN — J. W. RYZNAR
I. C. DIETZE — ARTHUR W. TRACY
J. J. HARWOOD — V. B. PIKE

CORRESPONDENTS

C. L. BULOW—*Non-Ferrous Metals*
R. W. FLOURNOY—*Pulp, Paper, Mining and Food*
J. J. HALBIG—*Ferrous Metals*
W. E. HUDDLESTON—*Petroleum Production and Pipe Lines*
HUGO W. WAHLQUIST—*Power*
GUSTAVE HEINEMANN—*Chemical Process*
R. H. BROWN—*Light Metals*
DERK HOLSTEYN—*Petroleum Refining*
H. O. SAUNDERS, JR.—*Telephone, Telegraph, Radio*
R. MCFARLAND—*Non-Metals*
L. M. MOSHER—*Transportation Industry*
T. E. LARSON—*Fresh and Salt Water*

BUSINESS STAFF

NORMAN E. HAMNER, *Managing Editor and Advertising Manager*
A. B. CAMPBELL *(Executive Secretary NACE) Business Manager*

GENERAL OFFICES

1061 M & M Building, No. 1 Main St.
Houston 2, Texas

Subscription: $9.00 per year to non-members: Member's dues $7.50, of which $3.75 are applied as subscription to CORROSION; Special rate, $4.00 per year for public libraries and libraries of educational institutions. Additional copies to members 50 cents, to non-members, $1.00. Foreign remittances should be by international postal or express money order or bank draft negotiable in the U. S. for an equivalent amount in U. S. funds. Entered as second class matter October 31, 1946, at the Post Office at Houston, Texas, under the act of March 3, 1879.

Corrosion is indexed Regularly by Engineering Index.

Corrosion

devoted entirely to CORROSION *research and control*

Published Monthly as its official journal, by the National Association of Corrosion Engineers, Inc., at Houston, Texas, U. S. A., as a permanent record of progress in corrosion control.

Vol. 9 — APRIL, 1953 — No. 4

CONTENTS

Page

Directory of NACE Regional and Sectional Officers ..... iv, v
Directory of Technical Practices Committees ..... viii, ix
Officers and Directors, National Association of Corrosion Engineers xiv

TECHNICAL SECTION

Proving Results by Publications 107
Evidence of Corrosion Failures in Drill Stem Members
By A. P. Farr 108
Discussion: Oliver Osborn, Page 113
Drill Stem Corrosion in West Texas
By Stanley C. Moore 112
Discussion: Oliver Osborn, Page 113
Electrochemical Behavior of Metals as a Basis for the Study of Corrosion
By R. Piontelli 115
The Corrosion Engineer Uses Plastics
By Frank L. Whitney, Jr. 123
Corrosion of Galvanized Steel in Soils
By Irving A. Denison and Melvin Romanoff 132
Corrosion of Low-Alloy Irons and Steels in Soils
By Irving A. Denison and Melvin Romanoff 141
ERRATA—Corrosion and Related Problems in Sea Water Cooling and Pipe Systems in H.M. Ships. Aluminum Alloys for Offshore Pipe Lines 131

NACE REGIONAL AND SECTIONAL NEWS

Page

Kanawha Valley Section Organized 2
Toronto Section Organized 2
Domestic Water Supply System Corrosion Pittsburgh Topic 2
Data on Valve Diaphragms Covered at St. Louis Meeting 2
NACE Calendar 2
Discussion Session Featured at Chicago 2
Atlanta Session Has Discussion 2
Aircraft Corrosion Discussed at Dallas 2
Southern New England Section 3
Microbiology, Inhibitors Topics at Philadelphia 4
Baltimore Section Meeting Dates 4
North East Region to Meet at Buffalo 5
New York Section to Hear Talk on Valves 5
Over 200 Pipeliners Attend Course 6
Pittsburgh Section Election Set 8
Central Oklahoma Section Elects 8
West Elected to Head S.E. Region 8
Fontana Speaks at Los Angeles 8
North Central Ballots Mailed 8
South East Region Meets May 7 8
Stress Corrosion is Houston Topic 10
Jack T. Martin Heads New Orleans-Baton Rouge Section 10
F. L. LaQue Heard at Houston 10
Stewart To Discuss Well Corrosion at Shreveport Section 11
Teche Section Hears Edwards 11
New Coating is Corpus Christi Topic 11
North Texas Section to Have Ladies' Night 11
San Francisco Section Hosts to Short Course Teachers 12
San Diego Section Organizes 12

GENERAL NEWS OF CORROSION INTEREST

Page

Topic of the Month—Phenolic-Butadiene-Acrylonitrile Polymers for Pipe and Pipe Fittings
By R. McFarland 1
Nominations for 1954 NACE Awards 8
Belgians Begin Publication on Corrosion 14
Book Reviews 14
Factors in Automobile Corrosion Discussed 14
New Abstract Source Added 14
New Products 16
AWWA Convention Scheduled May 10-15 23
New Officers and Directors Take Reins 25
Busy Week Attracts 1575 Registrants 25
Schmidt Is Named TP Committee Head 25
23 Technical Practices Committee Meetings Held 26
Sustained Growth Cited in Reports 26
Corrosion Terminology Glossary Started 28
Dunnington and Beck Get Junior Awards 29
Ewing and Burns Receive Annual Awards 30
1955 Conference Switched to Chicago 31
Three Added to Editorial Review Committee 31
Yearbook Publication Considered 32
Bibliography Publication to Be Speeded 32

Index to Corrosion Abstracts 33
Index to Advertisers 53

Copyright 1953 by the National Association of Corrosion Engineers. Reproduction of the contents, either as a whole or in part, is forbidden unless specific permission has been obtained from the Editor of CORROSION. Articles presented represent the opinions of their authors, and not necessarily those of the Editors of CORROSION, nor the Officers or Members of the National Association of Corrosion Engineers. Manuscripts to be considered for publication should be forwarded, together with illustrations, to the Editor of CORROSION, 1061 M & M Building, Houston 2, Texas.

Directory of NACE Regional and Sectional Officers

NORTH EAST REGION

L. B. DONOVAN, Director
Consolidated Edison Co.
of New York, Inc.
4 Irving Place
New York City.

GEORGE E. BEST, Chairman
Mutual Chem. Co. of America
1348 Block St.
Baltimore 31, Md.

KEMPTON H. ROLL, Vice-Chair.
Lead Industries Assoc.
420 Lexington Ave.
New York 17, N. Y.

W. R. BRIGGS, Sec.-Treas.
W. A. Briggs Bitumen Co.
3303 Richmond St.
Philadelphia 34, Pa.

• Baltimore Section

L. G. VON LOSSBERG, Chairman
Sheppard T. Powell Consulting
Chemical Engineers
330 North Charles Street
Baltimore, Maryland

ALLEN L. ALEXANDER, Vice-Chair.
1710 Oakcrest Drive
Alexandria, Virginia

RISQUE BENEDICT, Sec.-Treas.
Naval Research Laboratory
Washington 25, D. C.

• Greater Boston Section

EDWIN J. TITSWORTH, Chair.
Koppers Co., Inc., Tar
Products Division
250 Stuart St.
Boston 16, Mass.

JOHN SWIFT, Vice-Chairman
Arthur D. Little, Inc.
30 Memorial Drive
Cambridge 42, Mass.

J. D. BIRD, Sec.-Treas.
The Dampney Co.
1243 River, Hyde Park
Boston 36, Mass.

• Metropolitan New York Section

GEORGE C. HULL, JR., Chair.
Anglo-American Varnish Co.
55 Johnson St.
Newark 5, N. J.

MORTON BERMANN, Vice-Chair.
Brooklyn Union Gas Co.
197 St. James Place
Brooklyn, New York

F. J. LeFEBVRE, Sec.-Treas.
Electro Rust-Proofing Corp.
Box 178
Newark 1, N. J.

• Philadelphia Section

E. G. BRINK, Chairman
American Viscose Corp.
Marcus Hook, Pa.

H. H. BENNETT, Vice-Chair.
Socony-Vacuum Oil Co., Inc.
Paulsboro, N. J.

J. S. PETTIBONE, Sec.-Treas.
Am. Soc. Testing Mat.
1916 Race St.
Philadelphia 3, Pa.

• Pittsburgh Section

N. P. PEIFER, Chairman
Manufacturers Light
& Heat Co.
800 Union Trust Bldg.
Pittsburgh 19, Pa.

N. T. SHIDELER, Vice-Chair.
Pittsburgh Coke & Chemical
Corporation
Neville Island,
Pittsburgh 25, Pa.

F. E. COSTANZO, Sec.
Manufacturers Light &
Heat Company
2202 Vodeli St.,
Pittsburgh 16, Pa.

W. W. BINGER, Treasurer
Aluminum Co. of America
Research Laboratories
Box 772
New Kensington, Pa.

• Southern New England Section

F. R. MEYER, Chairman
Sou. New England Tel. Co.
New Haven, Conn.

A. W. TRACY, Vice-Chair.
American Brass Company
Waterbury, Conn.

GERALD R. BROPHY, Sec.-Treas.
International Nickel Co., Inc.
75 Pearl St.
Hartford, Conn.

• Western New York Section

WILLIAM O. BINDER, Chair.
Research Laboratories
Union Carbide & Carbon Corp.
Niagara Falls, N. Y.

J. E. SHIELDS, Vice-Chair.
Atox Corp.
3943 Buffalo Ave.
Niagara Falls, N. Y.

PAUL R. GUENTHER, Sec.-Treas.
Socony-Vacuum Oil Co., Inc.
503 Elk Street
Buffalo 5, N. Y.

NORTH CENTRAL REGION

FRANK L. WHITNEY, JR., Dir.
Monsanto Chemical Co.
1700 S. Second St.
St. Louis, Mo.

JACK H. LoPRETE, Chair.
Spray-Coat Engineers
775 S. Bayside St.
Detroit 25, Mich.

NORMAN A. KERSTEIN, Vice-Chair.
16817 Robson
Detroit, Michigan

JAMES F. HIRSHFELD, Sec.-Treas.
Hinchman Corp.
1208 Francis Palms Bldg.
Detroit 1, Mich.

• Chicago Section

C. A. VAN NATTA, Chairman
Plastic Lining Coatings
900-02 South Wabash Ave.
Chicago 5, Ill.

L. W. EWING, Vice-Chairman
Standard Oil Co. of Indiana
Pipe Line Dept.
910 Michigan Ave.
Chicago, Ill.

R. I. LINDBERG, Sec.
Sinclair Research Laboratories,
Inc.
400 E. Sibley Blvd.
Harvey, Ill.

H. W. DIAMOND Treas.
Morton Salt Co.
120 S. LaSalle St.
Chicago, Ill.

• Cleveland Section

C. N. DETRICK, Chairman
Williams & Co., Inc.
3700 Perkins Ave.
Cleveland, Ohio

W. E. BAKER, Vice-Chair.
Standard Oil Co. of Ohio
606 Standard Bldg.
Cleveland 13, Ohio

H. W. HOSFORD, JR., Sec.-Treas.
Harco Corp.
Box 7026
Cleveland 28, Ohio

• Detroit Section

L. D. COOK, Chairman
Wyandotte Chemical Corp.
Wyandotte, Mich.

W. R. CAVANAGH, Vice-Chair.
Parker Rust Proof Co.
2177 East Milwaukee
Detroit, Mich.

D. F. FINLAY, Secretary
Hinchman Corporation
1208 Francis Palms Bldg.
Detroit, Mich.

P. G. COATES, Treasurer
Michigan Bell Telephone Co.
312 Potawatomi Blvd.
Royal Oak, Michigan

• Eastern Wisconsin Section

ROBERT E. WICEN, Chair.
Chain Belt Co. of Milwaukee
1600 West Bruce St.
Milwaukee 4, Wis.

ROBERT A. HUSEBY, Vice-Chair.
A. O. Smith Corp.
3533 North 27th St.
Milwaukee, Wis.

HAROLD F. HAASE, Sec.-Treas.
2917 West Juneau Ave.
Milwaukee 8, Wis.

• Greater St. Louis Section

GEORGE A. FISHER, Chairman
International Nickel Co., Inc.
411 North Seventh St.
St. Louis, Mo.

OTTO H. FENNER, Vice-Chair.
Monsanto Chemical Co.
1700 S. Second St.
St. Louis, Mo.

ANDREW T. PICKENS, Sec.
C. K. Williams & Co.
2001 Lynch St.
East St. Louis, Ill.

CAMDEN A. COBERLY, Treas.
316 Oak Manor Lane
Webster Groves, Missouri

• Kanawha Valley Section

A. C. HAMSTEAD, Chairman
Carbide and Carbon Chemical Co.
South Charleston, W. Va.

R. I. ZIMMERER, Vice-Chair.
Westvaco Chemical Div.,
Food Machinery & Chemical Corp.
Drawer 8127, South Charleston,
W. Va.

CONRAD L. WIEGERS, Secretary
Allied Services Inc.
Spring & Bullitt Sts.
Station A, Charleston, W. Va.

W. R. CURLEY, Treasurer
Hope Natural Gas Co., Box 1951
Clarksburg, W. Va.

• Kansas City Section

L. F. HEVERLY, Chairman
Great Lakes Pipeline Co.
5425 Chadwick Rd.
Kansas City, Mo.

R. A. KELLEY, Vice-Chairman
Minnesota Mining & Mfg. Co.
4224 West 73rd Terrace
Prairie Village, Kans.

J. C. BERRINGER, Sec.-Treas.
Panhandle Eastern Pipe Line Co.
1221 Baltimore Ave.
Kansas City, Mo.

Directory of NACE Regional and Sectional Officers

• Southwestern Ohio Section

ROY O. McDUFFIE, Chairman
Dept. Chem. & Met. Eng.
University of Cincinnati
Cincinnati 21, Ohio

ARTHUR D. CASTER, Vice-Chair.
38 Arcadia Place
Cincinnati, Ohio

LEWIS M. LEDERER, Sec.
Inner-Tank Lining Corp.
1097 Wade St.
Cincinnati, Ohio

R. L. WOOD, Treasurer
323 Plum St.
Cincinnati, Ohio

SOUTH EAST REGION

E. D. McCAULEY, Director
American Cast Iron Pipe Co.
Box 2603
Birmingham, Alabama

JOHN B. WEST, Chairman
Chicago Bridge & Iron Co.
1818 Rhodes-Haverty Bldg.
Atlanta, Ga.

H. C. VAN NOUHUYS, Vice-Chair.
Southeastern Pipe Line Co.
Box 1737
Atlanta, Georgia

DAVID H. CHADWICK, Sec.-Treas.
Res. Dept, Phosphate Div.
Monsanto Chemical Co.
Anniston, Ala.

• Atlanta Section

J. FLYNN JOHNSTON, Chair.
American Tel. & Tel. Co.
1139 Hurt Bldg.
Atlanta, Ga.

RAYMOND F. TRAPP, Vice-Chair.
3431 Sherman Road
Hapeville, Ga.

ALEX M. ERGANIAN, Sec.-Treas.
Pipe Line Service Corp.
1734 Candler Bldg.
Atlanta, Ga.

• Jacksonville (Fla.) Section

HENRY T. RUDOLF, Chairman
Atlantic Coatings Co., Inc.
P. O. Box 2976
Jacksonville 3, Fla.

P. E. ALEXANDER, Sec.-Treas.
Dozier & Gay Paint Co.
P. O. Box 3176, Station F
Jacksonville, Fla.

SOUTH CENTRAL REGION

DERK HOLSTEYN, Director
Shell Oil Company
Box 2527
Houston, Texas

H. E. WALDRIP, Chairman
Gulf Oil Corp.
5311 Kirby Drive
Houston, Texas

THOMAS S. MOFFATT, JR., Vice-Chair.
Columbia Southern Chemical Corp.
Lawrence Drive
Corpus Christi, Texas

CLIFFORD L. BARR, Sec.-Treas.
Shell Oil Company,
Richards Building
New Orleans, La.

JOHN E. LOEFFLER,
Asst. Sec.-Treas.
Thornhill Craver Co.
Box 1184
Houston, Texas

• Central Oklahoma Section

DAN H. CARPENTER, Chairman
Sohio Petroleum Co.
1300 Skirvin Tower
Oklahoma City, Okla.

MARTIN L. STEFFENS, Vice-Chair.
Oklahoma Natural Gas Co.
Box 1620
Oklahoma City, Okla.

BRUCE D. OWEN, Sec.-Treas.
Southwestern Bell Tel. Co.
405 N. Broadway
Oklahoma City, Okla.

• Corpus Christi Section

JOHN W. NEE, Chair.
c/o Briner Paint Mfg. Co., Inc.
3713 Agnes St.
Corpus Christi, Texas

CHARLES F. WARD, Vice-Chair.
Magnolia Petroleum Co.
Refining Dept.
Box 1179
Corpus Christi, Texas

JOHN P. WESTERVELT, Sec.-Treas.
Pontiac Refining Co.
P. O Box 1581
Corpus Christi, Texas

• Houston Section

L. G. SHARPE, Chairman
Humble Pipe Line Co.
P. O. Drawer 2220
Houston 1, Texas

J. A. CALDWELL, Vice-Chair.
Humble Oil and Ref. Co.
Box 2180
Houston, Texas

R. C. BOOTH, Sec.-Treas.
5719 South Seas
Houston, Texas

• New Orleans-Baton Rouge Section

JACK T. MARTIN, Chairman
The Texas Company
Production Dept.
P. O. Box 252
New Orleans, La.

FRANK S. BIRD, Vice-Chair.
The California Co.
800 The California Co. Bldg.
1111 Tulane Ave.
New Orleans, La.

RUSSELL W. SCHUTT, Sec.-Treas.
Shell Oil Company
P. O. Box 193
New Orleans, La.

• North Texas Section

J. C. SPALDING, JR., Chair.
Sun Oil Company
Box 2880
Dallas, Texas

MORRIS BOCK, Vice-Chair.
Sun Oil Company
1405 North Zangs Blvd.
Dallas, Texas

MARYANN DUGGAN, Sec.-Treas.
Magnolia Petroleum Co.
Box 900
Dallas, Texas

• Permian Basin Section

JOHNNY H. SHELTON, Chair.
National Tank Co.
P. O. Box 665
Midland, Texas

LAMAR F. SUDDUTH,
1st Vice-Chair.
Stanolind Oil & Gas Co.
300 W. Illinois St.
Midland, Texas

JAY D. STAFFORD, 2nd Vice-Chair.
National Tank Co.
P. O. Box 665
Midland, Texas

WILLIAM A. HOPWOOD,
Sec.-Treas.
Tnemec Company, Inc.
2703 S. Colonial Drive
Odessa, Texas

• Sabine-Neches Section

CHRISTOPHER A. MURRAY, Chair.
Pure Oil Company
Box 237
Nederland, Texas

CHARLES A. RIDENOUR,
Vice-Chair.
Magnolia Petroleum Co.
P. O. Box 3311
Beaumont, Texas

V. M. BROWN, Sec.-Treas.
627½ Cleveland
Lake Charles, La.

• Shreveport Section

M. J. OLIVE, Chairman
Arkansas Natural Gas Corp.
Shreveport 4, La.

W. F. LEVERT, Vice-Chairman
United Gas Pipe Line Co.
P. O. Box 1407
Shreveport, La.

A. W. WHEELER, Secretary
Graybar Electric Co.
3621 Greenway Place
Shreveport, La.

J. O. GRIFFIN, Treasurer
Texas Eastern Gas Trans. Corp.
Texas Eastern Bldg.
Shreveport, La.

• Teche Section

GEORGE M. HARPER, Chairman
Union Oil Co. of California
Box 421
Abbeville, Louisiana

GUS VOGLER, Vice-Chair.
Allen Cathodic Protection Co.
P. O. Box 264
Lafayette, La.

J. H. WATERFIELD, Sec.-Treas.
United Gas Corp.
New Iberia, La.

• Tulsa Section

JACK P. BARRETT, Chairman
Stanolind Oil & Gas Co.
P. O. Box 591
Tulsa, Oklahoma

LLOYD NELSON, Vice-Chair.
Shell Pipe Line Co.
1123 E. Second
Cushing, Oklahoma

HUGH A. BRADY, Secretary
Pipe Line Anode Corp.
P. O. Box 996
Tulsa, Oklahoma

EDWARD A. BARTOLINA, Treasurer
Moorlane Company
P. O. Box 1679
Tulsa, Oklahoma

WESTERN REGION

L. L. WHITENECK, Director
Long Beach Harbor Dept.
1333 El Embarcadero
Long Beach 2, Calif.

E. H. GRIZZARD, Chairman
Signal Oil & Gas Co.
811 West 7th St.
Los Angeles, Cal.

AUSTIN S. JOY, Vice-Chairman
Bechtel Corp., Somastic Div.
Box 457
Wilmington, Cal.

ROBERT H. KERR, Sec.-Treas.
Southern California Gas Co.
Box 3249 Terminal Annex
Los Angeles, Cal.

• Los Angeles Section

K. T. VANGSNES, Chair.
The Vanode Company
880 E. Colorado St.
Pasadena, California

S. J. ARTESE, Vice-Chair.
Shell Oil Company
Box 728
Wilmington, Calif.

S. K. GALLY, Sec.-Treas.
1061 Mar Vista Ave.
Pasadena 6, Calif.

• Salt Lake Section

HARRY R. BROUGH, Chairman
Mountain Fuel Supply Co.
36 South State St.
Salt Lake City, Utah

GEORGE R. HILL, Vice-Chair.
Fuel Technology Dept.
University of Utah
Salt Lake City, Utah

JOHN W. COX, Sec.-Treas.
Utah Oil Refining Co.
P. O. Box 898
Salt Lake City 10, Utah

• San Diego Section

L. E. MAGOFFIN, Chairman
(Temporary)
California Water & Telephone Co.
19 West 9th St.
National City, Calif.

DALLAS G. RAASCH, sec.-Treas.
(Temporary)
La Mesa, Lemon Grove,
Spring Valley Irrigation District,
Box 518, La Mesa, Calif.

• San Francisco Bay Area Section

G. A. WORKS, JR., Chairman
Union Oil Co. of Cal.
Oleum, Cal.

D. R. LOPER, Vice-Chair.
Standard Oil Co. of Cal.
225 Bush St.
San Francisco, Cal.

T. J. SMITH, Sec.-Treas.
Electric Steel Foundry Co.
249 First St.
San Francisco 5, Cal.

CANADIAN REGION

(Temporary)

G. I. RUSSELL, Chairman
Union Gas Co. of Canada, Ltd.
Chatham, Ontario

L. W. SHEMILT, Vice-Chair.
University of British Columbia
Vancouver, B. C.

G. M. McPHERSON, Sec.-Treas.
300 Ninth Ave. W.
Imperial Oil Ltd.
Calgary, Alta.

FOR LOWER MAINTENANCE COSTS
WRITE INTO YOUR SPECIFICATIONS

"OUTSIDE TO BE TYGON-COATED"

The perfect companion for TYGON PAINT is TYGO-RUST, the "no-prep" vinyl primer.

Don't take a chance on avoiding heavy maintenance and repair costs caused by corrosion. *Be sure.* Specify —"outside to be Tygon-coated."

Tygon Plastic Paint Coatings have been proved by years of exposure to such corrosives as sulphuric, hydrofluoric, nitric, hydrochloric, sodium hypochlorite, potassium hydroxide (in fact, Tygon Plastic Paint Coatings will resist the fumes of virtually all acids and alkalies except glacial acetic and fuming nitric).

Tygon Paint is inert to most alcohols, to fresh or salt water, to oil and grease . . . stands up under abuse that quickly kills ordinary coatings.

There are other things about Tygon Paint Coatings you'll like: no cracking, checking or crazing; a really *flexible* film that "gives" under impact without chipping or flaking; high electrical insulating properties; a film that is non-toxic, non-contaminating and non-flammable.

Tygon Plastic Paint Coatings are available in colors, too: white, red, gray, green, aluminum, black and clear.

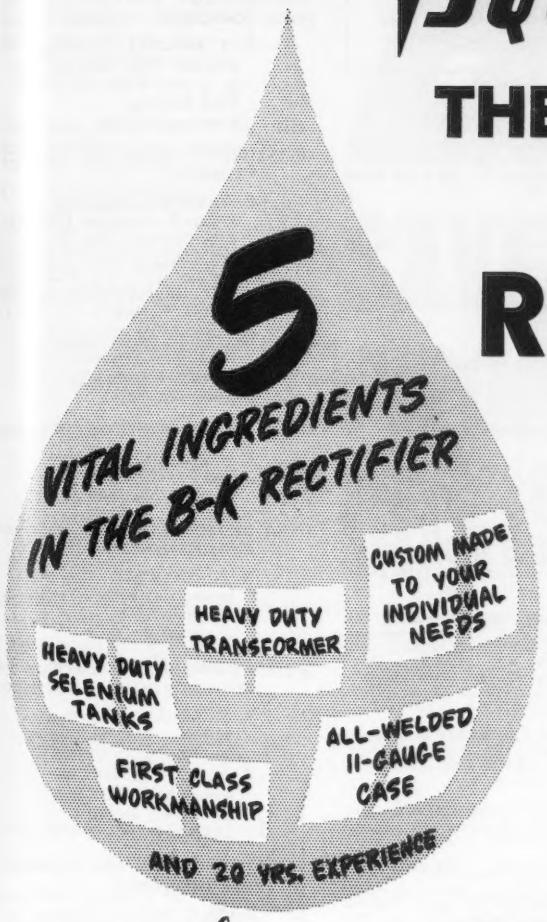
ANTI-CORROSIVE MAINTENANCE
in your own plant . . .

Your own maintenance crew can easily use Tygon Plastic Paint Coatings to protect walls, structural steel, tank exteriors, fume hoods and ducts, etc. Apply by spray gun or brush—air dries quickly. Use on wood, metal or concrete. Would you like a free test sample? *Write today*

PLASTICS & SYNTHETICS DIVISION
U. S. STONEWARE
Akron 9, Ohio

B-K HELPS YOU SQUEEZE

THE BEST DROPS FROM YOUR RECTIFIER DOLLAR . . .



- Dependability
- Quality Workmanship
- Heavy Duty Construction
- Highest Quality Auxiliary Equipment
- Built to Your Specifications

LET YOUR NEAREST B-K REPRESENTATIVE HELP YOU WITH YOUR NEXT INSTALLATION

COMPLETE CATHODIC PROTECTION EQUIPMENT — B K

Brance-Krachy Co. INC.

4411 NAVIGATION • P.O. Box 1724 • HOUSTON

For Full Information, Write, Wire or Teletype (HO-561)
4411 NAVIGATION BLVD., P. O. BOX 1724, HOUSTON
2850 E. FLORENCE ST., HUNTINGTON PARK, CALIF.
P. O. BOX 13, UPPER MONTCLAIR, NEW JERSEY
1344 GRISWOLD ST., PORT HURON, MICH.

BRANCE-KRACHY CO., INC.
P. O. Box 1724, Houston, Texas
Please send me details on your B-K Rectifiers.
Name_____
Company Address_____
City_____ State_____

DIRECTORY OF TECHNICAL PRACTICES COMMITTEES

H. W. Schmidt, Chairman
1313 Helen St.,
Midland, Michigan

EX-OFFICIO MEMBERS

WALTER F. ROGERS
AARON J. WACHTER
A. B. CAMPBELL

(Chairmen of all TP sub-committees listed below are members of the full committee)

TP-1 CORROSION OF OIL AND GAS WELL EQUIPMENT (Formerly Condensate Well Corrosion)

H. L. BILHARTZ, Chairman
Atlantic Refining Co.
Box 2819
Dallas, Texas

R. C. BUCHAN, Vice-Chairman
Humble Oil & Ref. Co.
Box 2180
Houston, Texas

TP-1A Pacific Coast. J. J. Browne, vice-chairman; General Petroleum Corp., Box 726, Wilmington, Cal.

TP-1B Condensate Well Corrosion. R. C. Buchan, Chairman, Humble Oil & Refining Co., Houston, Texas.

TP-1C Sweet Oil Well Corrosion. H. L. Bilhartz, chairman; H. E. Greenwell, vice-chairman, both with Atlantic Refining Co., P. O. Box 2819, Dallas.

TP-1D Sour Oil Well Corrosion. Co-chairmen: J. A. Caldwell, Humble Oil & Ref. Co., Box 2180, Houston, Texas, and R. L. Elkins, Shell Oil Corp., Box 1509, Midland, Texas.

TP-1F Metallurgy—Oil and Gas Well Equipment. F. A. Prange, chairman; Phillips Petroleum Co., Bartlesville, Okla.

TP-1G Sulfide Stress Corrosion. R. S. Treseder, Shell Development Co., Emeryville, Cal.

TP-1H Corrosion of Oil String Casing. Jack L. Battle, Humble Oil & Ref. Co., Box 2180, Houston, Texas

TP-1J Oil Field Structural Plastics. W. M. Thornton, Atlantic Refining Co., P. O. Box 2819, Dallas, Texas; B. W. Bradley, Shell Oil Company, Tulsa, Okla., co-chairmen.

TP-2 GALVANIC ANODES FOR CATHODIC PROTECTION

WALTER P. NOSER, Chairman
Humble Pipe Line Co., Drawer 2220
Houston, Texas

H. A. ROBINSON, Vice-Chairman
The Dow Chemical Co.
616 East Grove St.
Midland, Mich.

TP-2A Correlation of Data From Operating Installations. L. R. Sheppard, Shell Pipe Line Corp., Houston, Texas.

TP-3 ANODES FOR USE WITH IMPRESSED CURRENTS

DONALD H. BOND, Chairman
The Texas Pipe Line Company
P. O. Box 2332, Houston 1, Texas

A. W. PEABODY, Vice-Chairman
263 Houston Ave.
Jackson 9, Miss.

TP-4 MINIMUM CURRENT REQUIREMENTS FOR CATHODIC PROTECTION

TP-5 CORROSION PROBLEMS INVOLVED IN PROCESSING AND HANDLING CHEMICALS

H. W. SCHMIDT, Chairman
The Dow Chemical Co.
Midland, Mich.

PAUL J. GEGNER, Vice-Chairman
Columbia-Southern Chemical Corp.
Barberton, Ohio

TP5A Corrosion by Sulfuric Acid. C. L. Bulow, chairman; Bridgeport Brass Co. 30 Grand St., Bridgeport, Conn. W. A. Luce, vice-chairman; The Duriron Co., Box 1019, Dayton, Ohio

TP-5C Sub-Surface Corrosion by Alkaline Solutions (Caustic Embrittlement). C. F. Pogacar, chairman; Atlantic Refining Co., 260 South Broad St., Philadelphia, Pa.

TP-5F Corrosion by Chlorine. R. I. Zimmerer, chairman; Westvaco Chemical Division, Food Machinery & Chemical Corp., Drawer 8127, Charleston 3, West Virginia.

TP-5G Corrosion by Nitric Acid. J. L. English, chairman; Oak Ridge National Laboratory, P. O. Box P, Oak Ridge, Tenn.

TP-6 PROTECTIVE COATINGS

KENNETH TATOR, Chairman
Consulting Engineer, Montour St. Extension, Coraopolis, Pa.

PACIFIC (West Coast Div.)
L. L. Whiteneck, Chairman
Long Beach Harbor Dept.
Long Beach 7, Cal.

TP-6A Organic Coatings and Linings for Resistance to Chemical Corrosion. Kenneth Tator, Chairman.

TP-6B Protective Coatings for Resistance to Atmospheric Corrosion. G. G. Sward, chairman; National Paint, Varnish & Lacquer, 1500 Rhode Island Ave., N.W., Washington, D. C. L. L. Sling, vice-chairman; Sline Industrial Painters, 2612 Gulf Terminal Drive, Houston 23, Texas.

TP-6C Protective Coatings for Resistance to Marine Corrosion. Raymond P. Devoluy, Chairman. C. A. Woolsey Paint & Color Co., 229 E. 42nd St., New York 17, N. Y.

TP-6E Protective Coatings in Petroleum Production. Jack P. Barrett, Stanolind Oil and Gas Company, Tulsa, Okla.

TP-6G Surface Preparation for Organic Coatings. A. J. Liebman, chairman; Dravo Corp., Dravo Bldg., Pittsburgh 22, Pa. L. R. Whiting, Bakelite Corp., 30 East 42nd St., New York 17, N. Y.

TP-6H Glass Linings and Vitreous Enamel. G. H. McIntyre, Chairman. Ferro-Enamel Corp., Harvard & 56th St., Cleveland 5, Ohio.

TP-6K Corrosion Resistant Construction with Masonry and Allied Materials. Robert R. Pierce, Chairman, Pennsylvania Salt Manufacturing Co., 1000 Widener Bldg., Philadelphia, Pa.

TP-7 MATERIALS FOR USE AT HIGH TEMPERATURES

M. A. SCHEIL, Chairman
Director Metallurgical Research
A. O. Smith, Corporation
Milwaukee, Wisconsin

TP-8 CORROSION BY WATERS

V. V. KENDALL, Chairman
National Tube Company, Frick Building, Pittsburgh 30, Pennsylvania

TP-9 CORROSION INHIBITORS

FRANKLIN M. WATKINS, Chair.
Sinclair Research Laboratories, Inc.
400 E. Sibley, Blvd.
Harvey, Illinois

ROBERT S. WISE, Vice-Chair.,
National Aluminate Corp.
6216 West 66th Pl.
Chicago, Ill.

TP-10 CORROSION FATIGUE

V. V. KENDALL, Chairman
National Tube Division,
U. S. Steel Corp.
Frick Building
Pittsburgh 30, Pa.

TP-11 IDENTIFICATION OF CORROSION PRODUCTS

C. E. IMHOFF, Chairman
Research Supervisor, Chemical Lab.
Allis-Chalmers Mfg. Co.
Milwaukee 1, Wis.

TP-12 EFFECT OF ELECTRICAL GROUNDING ON CORROSION

GLEN APPLEMAN, Chairman
Pennsylvania Power & Light
Ninth & Hamilton St.
Allentown, Pa.

TP-13 ANNUAL LOSSES DUE TO CORROSION

F. N. ALQUIST, Chairman
The Dow Chemical Co.
Midland, Michigan

TP-14 INSTRUMENTS FOR CORROSION MEASUREMENTS

H. N. HAYWARD, Chairman
Engineering Experiment Station
University of Illinois
Urbana, Ill.

TP-15 CORROSION CONTROL IN THE TRANSPORTATION INDUSTRIES

K. K. KESSLER, Chairman
Baltimore & Ohio Railroad
Baltimore 23, Maryland

G. M. MAGEE, Vice Chair.
Assoc. Amer. Railroads
Technology Center
Chicago 16, Ill.

TP-16 ELECTROLYSIS AND CORROSION OF CABLE SHEATHS

IRWIN C. DIETZE, Chairman.
Dept. of Water & Power,
City of Los Angeles, Cal.

TP-16A Stray Railway Current Electrolysis. M. D. Fletcher, Chairman, Illinois Bell Telephone Co., 212 West Randolph St., Chicago 6, Ill. J. Svetlik, Co-chairman, Northern Indiana Public Service Co., 5265 Hohman Ave., Hammond, Ind.

TP-16B Corrosion of Lead and Other Metallic Sheaths. B. B. Reinitz, Chairman, The Okonite-Callender Cable Co., Inc., 730 Twenty-first St., Paterson, N. J. F. J. Maitland, Co-chairman, American Telephone & Telegraph Co., 32 Sixth Ave., New York 13, N. Y.

TP-16C Cathodic Protection of Cable Sheaths. R. M. Lawall, chairman, American Telephone & Telegraph Co., 1538 Union Commerce Bldg., Cleveland 14, Ohio. W. J. Schaefner, co-chairman, Cincinnati Gas & Electric Co., Cincinnati 2, Ohio.

TP-16D Tests and Surveys. L. J. Gorman, Chairman, Robin Beach Engineers Associates, 32 Court St., Brooklyn 2, N. Y. Frank E. Kollman, Co-chairman, Consolidated Edison Co. of New York, 4 Irving Place, New York 3, N. Y.

TECHNICAL PRACTICES COMMITTEES' DIRECTORY

(Continued from Page viii)

TP-16E *Corrosion and Protection of Pipe-Type Cables. Frank Kahn, Chairman, Philadelphia Electric Co., 2301 Market St., Philadelphia 3, Pa.*

TP-16F *Nonmetallic Sheath Coatings. Geo. H. Hunt, Chairman, Simplex Wire & Cable Co., 79 Sidney St., Cambridge 39, Mass.*

TP-17 STANDARDIZATION OF PROCEDURES FOR MEASURING PIPE COATING CONDUCTANCE

W. E. HUDDLESTON, Chairman
Huddleston Engineering Co.
Bartlesville, Okla.

TP-18 INTERNAL CORROSION OF FACILITIES FOR STORAGE AND TRANSPORTATION OF PETROLEUM

L. G. SHARPE, Chairman
Humble Pipe Line Co.
Houston, Texas

TP-18A *Internal Sour Crude Corrosion of Pipe Lines and Tanks, R. L. Bullock, chairman; Interstate Oil Pipe Line Co., Box 1107, Shreveport, La. J. N. Hunter, Jr., vice-chairman; Service Pipe Line Co., Box 1979, Tulsa, Okla.*

TP-18B *Internal Corrosion of Products Pipe Lines. Ivy M. Parker, chairman; Plantation Pipe Line Co., Box 423, Bremen, Ga. Raymond Hadley, vice-chairman; Susquehanna Pipe Line Co., 1608 Walnut, Philadelphia 3, Pa.*

TP-19 CORROSION BY DE-ICING SALTS

F. E. KULMAN, Chairman
Consolidated Edison Company of N. Y., Inc.
4 Irving Place
New York City

Lapel Pins

Approx. Size

Approximately 7/16 inches high, gold, inlaid with bright red enamel background to "NACE" and deep blue enamel background to words "CORROSION CONTROL." Ruby center.

•

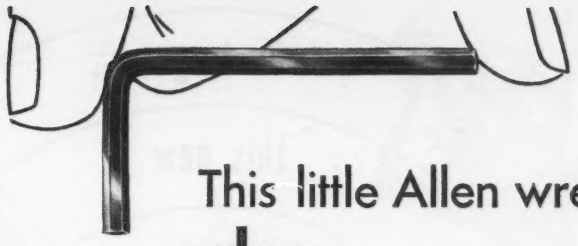
For Association Members Only

$7

Address Orders to
A. B. Campbell, Executive Secretary

NATIONAL ASSOCIATION OF CORROSION ENGINEERS

1061 M & M Bldg., Houston 2, Texas



This little Allen wrench **plus**.....

Quikupl®

SAVED US 37% ON PIPING INSTALLATION COSTS

SAYS
CHARLES VOJIK
ASSISTANT SUPERINTENDENT
NEWS SYNDICATE CO., INC.

"Acid condensate draining through existing galvanized lines was eating its way right through the pipe wall. We knew the remedy to be stainless steel, but shut-down was costly and the job difficult, since it was practically all overhead work and ran through three floors.

Quikupl provided the answer. The entire job was completed in 18 hours and we had none of the headaches that go with threading, flaring or welding stainless steel. We estimate that Quikupl saved us 37% on installation, in addition to making a very simple job out of a tough one."

BULLETIN Q100

Get the full story of this amazing stainless steel fitting which permits quick assembly and disassembly of stainless pipes or tubing without threading, flaring or welding.

Write for Bulletin Q100 today.

THE **COOPER ALLOY** FOUNDRY CO. • HILLSIDE, NEW JERSEY

NAME _____

POSITION _____

COMPANY _____

ADDRESS _____

CITY _____ STATE _____

Gun wrapped in VPI bag is ready to fire as soon as it has been unwrapped.

A remarkable new compound called VPI* now has rust on the run. VPI protects ferrous metals against corrosion during transit or storage, by its *vapors.*

VPI-coated wrapping paper is the most widely used method of putting the vapor to work. Metals are simply wrapped in the VPI paper and the vapors given off inhibit rust. Proper wrapping and storage will give protection up to 15 years.

VPI, made with Monsanto Dicyclohexylamine, is also available in crystal form. The crystals may be blown on metal surfaces or into machinery. After packaging to seal in the vapors, you can be assured of effective protection against rust. With VPI there is no greasing or degreasing—no skilled labor required.

VPI gives all-weather protection, even in 100% humidity. For information on this new method of fighting corrosion, write MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, 800 North Twelfth Blvd., St. Louis 1, Missouri.

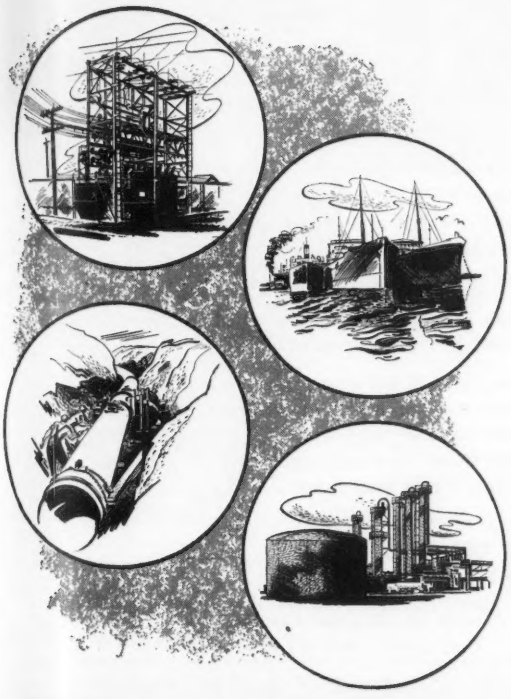
**Reg. U. S. Pat. Off. by Shell Development Company*

MONSANTO
CHEMICALS—PLASTICS
SERVING INDUSTRY...WHICH SERVES MANKIND

VPI PROTECTS: Aircraft engines, Precision tools, Auto body stampings, Military weapons, Tractors & Heavy equipment, Steel specimens, Finished metal stock, Steel drums, Gears & bearings, Wire & Steel strap, Lathes & Thread grinders, Cigarette lighters, Tank truck interiors, Automotive water pumps, Diesel engines and other metal equipment.

with NATIONAL Graphite Ground Anodes

TRADE-MARK



SILENTLY and unseen, corrosion has laid waste *billions of dollars worth* of underground and submarine structure in the past year. The most efficient means of preventing such damage is cathodic protection, using graphite anodes.

A properly designed system of impressed-current anodes, utilizing strategically placed "National" graphite ground rods, will not only *retard* corrosion but will entirely *eliminate* it.

Only such a system provides:

Controlled protection to match changing conditions of soil and weather.

Long life and **sustained** efficiency without attention.

Complete **dependability** at low overall cost.

Standard grades in sizes designed to meet specific needs are available in stock for immediate delivery. Consult one of the many reliable engineering firms specializing in corrosion prevention . . . or write direct to NATIONAL CARBON COMPANY for suggestions on how to overcome your particular corrosion problem.

Send for Catalog Section S-6510

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.
District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco
IN CANADA: National Carbon Limited, Montreal, Toronto, Winnipeg

OTHER NATIONAL CARBON PRODUCTS

HEAT EXCHANGERS • PUMPS • VALVES • PIPING • TOWERS • TOWER PACKING • SULPHURIC ACID CUTTERS
HYDROCHLORIC ACID ABSORBERS • STRUCTURAL CARBON • BUBBLE CAPS • BRICK • GRAPHITE ANODES • BRUSHES

Meet a metal that curbs corrosion, erosion and metal-to-metal wear ...NI-RESIST

THESE NI-RESIST CASTINGS . . . produced by ABRASIVE ALLOY CASTING CO., Bridgeboro, N. J., replaced bronze parts in pumps manufactured by KINGSFORD FOUNDRY AND MACHINE WORKS, Oswego, N. Y. They are 18" circulating pumps, driven by 200 H.P. at 690 R.P.M., handling 30 ft. head of 1.2 specific gravity glycerine at the rate of 11,000 G.P.M.

Resembling austenitic stainless steel in many of its characteristics but possessing the wear resistance, machinability and other useful properties of gray iron, NI-RESIST® provides a unique combination of properties at moderate cost...

Shown above are Ni-Resist castings that have given peak performance since November 1950, in a pump originally made of bronze for use by a large petro-chemical company.

And the reason for this performance? Ni-Resist curbs not only corrosive attacks of *acids*, *alkalies* and *salts*, but is highly resistant to galling and metal-to-metal wear.

Investigate Ni-Resist for other properties, too... machinability, heat resistance, electrical properties, and for controlled thermal expansion.

Several types of Ni-Resist are available to meet a variety of industrial demands. Get full information... mail coupon now.

At the present time, the bulk of the nickel produced is being diverted to defense, but nickel is obtainable for the production of NI-RESIST for many end uses in defense and defense supporting industries. There are authorized producers, from coast to coast, equipped to produce Ni-Resist castings in all common forms and shapes.

THE INTERNATIONAL NICKEL COMPANY, INC.
Dept. 20, 67 Wall Street, New York 5, N. Y.
Please send me booklets entitled, "Engineering Properties and Applications of Ni-Resist," and, "Buyers' Guide for Ni-Resist Castings."

Name _____ Title _____

Company _____ Address _____

City _____ State _____

EMBLEM OF INCO SERVICE TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

You can

Hang your hat

on the specifications of

PITT CHEM *MODIFIED* Pipeline Enamel

YOU don't have to guess about the uniform top quality of *Pitt Chem* Modified Enamel. Look at its written specifications —check its softening point, penetration, ash, etc.—and you'll know the rigid standards each drum *must* meet. Then watch a pipeline crew roll when they're coating with *Pitt Chem,* and you'll know that these enamels actually do heat up faster, flow better from kettle to pipe and coat more pipe per day.

Pitt Chem's *specified* top quality means better protection underground, too, for it allows a better bond and greater resistance to soil stresses and varying service temperatures. ● Write today for *Pitt Chem* specification sheets . . . or any help you may need on your particular coating problem.

★ Standard Grade Tar Base Enamel
★ Modified Grade Tar Base Enamel
★ Plasticized Grade Tar Base Enamel
★ Cold Applied Tar Base Coatings

PROTECTIVE COATINGS DIVISION
PITTSBURGH
COKE & CHEMICAL CO.
Grant Building · Pittsburgh 19, Pa.

W&D 4598 B

COAL CHEMICALS • AGRICULTURAL CHEMICALS • FINE CHEMICALS • PROTECTIVE COATINGS • PLASTICIZERS • ACTIVATED CARBON • COKE • CEMENT • PIG IRON

THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

(a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.

(b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.

(c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.

(d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.

(e) To promote standardization of terminology, techniques, equipment and design in corrosion control.

(f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.

(g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.

(h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 1061 M & M Building, No. 1 Main Street, Houston 2, Texas.

Officers, 1953-54

President.....WALTER F. ROGERS
Houston, Texas

Vice-President.....AARON J. WACHTER
Emeryville, Cal.

Treasurer.....R. A. BRANNON
Houston, Texas

Executive Secretary.....A. B. CAMPBELL
1061 M & M Building, Houston 2, Texas

Directors

President

WALTER F. ROGERS.....1953-54
Gulf Oil Corporation, Houston

Vice-President

AARON J. WACHTER.....1953-54
Shell Development Company, Emeryville, Cal.

Treasurer

R. A. BRANNON.....1953-54
Humble Pipe Line Company, Houston

Past President

M. G. FONTANA.....1953-54
Ohio State University, Columbus

Representing Active Membership

W. F. FAIR, JR.....1953-56
Koppers Co., Westfield, N. J.

ROBERT L. BULLOCK.....1953-56
Interstate Oil Pipe Line Co., Shreveport, La.

NORMAN HACKERMAN.....1952-55
University of Texas, Houston

L. A. HUGO.....1951-54
Phillips Petroleum Co., Bartlesville, Okla.

Representing Corporate Membership

J. PAT CASEY, JR.....1953-56
The Crane Company, Chicago, Ill.

H. P. GODARD.....1952-55
Aluminium Laboratories, Ltd., Kingston, Ont.

V. V. KENDALL.....1952-55
United States Steel Corp., Pittsburgh, Pa.

H. A. HUMBLE.....1951-54
Dow Chemical Corp., Midland, Mich.

C. P. LARRABEE.....1951-54
United States Steel Corp., Vandergrift, Pa.

Representing Regional Divisions

DERK HOLSTEYN.....(South Central) 1953-56
Shell Oil Company, Houston, Texas

ROBERT J. LAW.....(Canadian) Provisional
International Nickel Co. of Canada, Ltd., Toronto

L. L. WHITENECK.....(Western) 1952-55
Board of Harbor Commissioners, Long Beach, California

E. D. McCAULEY.....(South East) 1952-54
American Cast Iron Pipe Co., Birmingham, Ala.

L. B. DONOVAN.....(North East) 1951-54
Consolidated Edison Co. of N. Y., New York City

Directors Ex Officio

E. P. NOPPEL, Chairman Policy and Planning Committee
Ebasco Services, Inc., New York, N. Y.

R. B. HOXENG, Chairman Publication Committee
United States Steel Corp., Pittsburgh, Pa.

L. A. BALDWIN, Chairman Regional Management Committee
Johns-Manville Sales Corp., New York, N. Y.

Corrosion

OFFICIAL MONTHLY PUBLICATION

National Association of Corrosion Engineers

An Association of Individuals and Organizations Concerned with Control of Corrosion

1061 M & M Building Houston 2, Texas

Vol. 9 April, 1953 No. 4

Proving Results by Publications

WHEN the National Association of Corrosion Engineers was organized some nine years ago it was assumed there was a need for the organization and that there were benefits to be derived from the exchange of corrosion information. Now that the organization is approaching its tenth anniversary, it is appropriate to examine the record to see if the initial premise on which the organization was founded was sound.

While this evaluation of results must of necessity include numbers (there are now more than 4000 members of NACE), it is more significant to weigh concrete achievements such as the published results of corrosion investigations and the current significance of the organization. Obviously there must be a delay between the fact of organization and the accomplishment of results. There has been sufficient time for NACE to have marked some achievements—and it has done so.

So far the association has published or participated in the publication of numerous books, pamphlets and other materials on corrosion. Of these publications only a few need be mentioned and of those few perhaps the most important from the standpoint of corrosion research are the bibliographies of abstracts of corrosion literature, these same abstracts published on punch cards and the association's monthly magazine, CORROSION. An ambitious schedule for publication of volumes of corrosion abstracts has been laid out. This year NACE plans to issue a volume containing abstracts of material printed in 1948 and 1949. Next year it hopes to publish another biennium of abstracts, those printed in 1950 and 1951. In 1955 it plans to issue a book abstracting articles printed in 1952 and 1953 and in 1956, those printed in 1954, plus a 10-year index to all volumes.

Concurrently plans have been made to improve CORROSION magazine both in quantity and quality so that it will continue to reflect the interests of association members. The growing awareness of the merits of the association's monthly publication has attracted technical material from such widely separated points as the Union of South Africa, Holland and Japan.

Reports of the association's technical committees soon will begin to appear in greater numbers as the research terms for projects begin to mature. While several interim reports and one final report have been issued, it is expected that these will be more frequent in the immediate future. These reports have attracted wide attention and have been disseminated wherever there is extensive industrialization.

In cooperation with other technical and trade groups the association has published numerous bulletins and reports. These have had wide and enthusiastic reception. There is reason to believe these cooperative activities will increase rather than otherwise. The association owes a debt of gratitude to the numerous technical and industry groups that have given their cooperation in making many of NACE's activities possible. Their continued cooperation is expected so that the good work of reducing the damage from corrosion may continue.

The value of NACE has been underlined by its many millions of published words and by the prospect of uncounted millions more to come. This recording of progress, which permits freer interchange of information, is vital to continued success in mitigation of corrosion losses. Good things are planned for the assistance of the corrosion engineer, as is indicated herein. These published works, while by no means the whole of NACE's achievement, are nevertheless that part which is best suited to critical inspection. Much has been done. Very much more remains to be done. The published records are the stepping stones to further progress.

Evidence of Corrosion Failures In Drill Stem Members *

By A. P. FARR*

Abstract

Corrosion fatigue occurs in drill stems during drilling operations, cracks developing as a result of simultaneous action of cyclic stressing and corrosion pitting. Fatigue failures will occur without the presence of corrosion, but they occur quicker with corrosion present. Efforts to reduce corrosion fatigue failures were made by Hughes in 1932 when it was recommended a protective coating be applied or that a zinc wire be wrapped around the pipe under the counterbore of the tool joint. This problem was solved by welding the tool joint to the pipe, preventing the mud from reaching threads in the vulnerable zone. Zones of various drill stem members with greatest susceptibility to corrosion are illustrated. Failures in zones adjacent to unengaged threads in bottom of drill collar are vastly accelerated under corrosive conditions.

It is possible, by inspection, to anticipate corrosion fatigue failures by detection of cracks. Preliminary tests indicate that under corrosion fatigue conditions depth of a crack for a given length is proportional to the severity of corrosion.

Corrosion of drill collar boxes is frequent and serious. Practically all failures of drill stem members result in difficult fishing jobs.

CORROSION of drill stem may be divided into two classifications. First, that which occurs during storage, and second, that which occurs during operation. While the first is not to be ignored, it is generally less harmful and more easily controlled than the second. Corrosion of the second type, which is known as corrosion fatigue, occurs during drilling operations and is far more damaging to drill stem than corrosion which occurs during storage or stressless corrosion.

The pits produced in steel, unstressed or under static stress, are generally saucer-shaped and this shape is maintained as corrosion proceeds. However, under cyclic stressing sharp deep pits are formed and as corrosion fatigue continues many of the pits become the origin of cracks which are filled with corrosion products. Finally failure occurs by the progression of one of the cracks across the section of the steel involved.

Figure 1 shows schematically the components which make up the portion of a drill stem that operates in the hole. All of these members may be subjected to corrosion and unquestionably all are subjected to fatigue stresses. Examples of each of these members will be shown later in section. Drill pipe, tool joints and drill collars are equipped with various types of threaded connections. The various types of connections will not be discussed specifically, but rather incidentally, in pointing to locations in the various constructions where failures have been experienced.

Fatigue stresses in drill stem members result when the drill stem is rotated while it is bent. During rotation, alternate tensile and compressive stresses are imposed on the bent section of the drill stem. If the imposed stresses are above the so-called endurance limit, fatigue failures will occur even in the absence of corrosion. Such failure occur when running the pipe in compression with an insufficient number or weight of drill collars. When corrosion occurs simultaneously with fatigue action, the cycles to produce failure at a given stress are markedly reduced. In fact, it is generally accepted that steel has no endurance limit in corrosion fatigue. In other words, no corrodible drill stem can last indefinitely under conditions of repeated stress and corrosion.

According to Dr. Westcott[1], the damaging effect of the simultaneous action of corrosion and cyclic stressing on metals was first mentioned by Haigh in 1917.

Hughes Tool Company's first encounter with failure wherein corrosion fatigue appeared to be the culprit occured in 1932 in the Rita Santa Field of West Texas. The trouble encountered was failure through the pipe upset at the last engaged thread on tool joints having regular API pipe ends. A

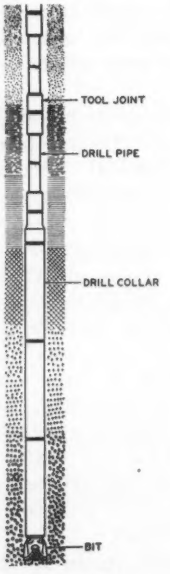


Figure 1

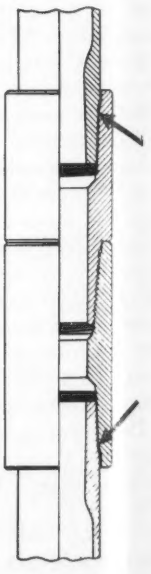


Figure 2

★A paper presented at a meeting of Houston Section, National Association of Corrosion Engineers, March 18, 1952. Submitted for publication March 25, 1952.

number of such failures occurred beginning 17 days after drilling was started.

A laboratory investigation was made wherein small polished unnotched samples of SAE 1045 steel were fatigue tested in air as well as in samples of drilling mud from the well where the above trouble was experienced. Figure 3 shows the fatigue curves which were developed in these tests. The method of testing might now be considered crude since the drilling fluid was merely dripped onto the test specimen surface during testing. The results, however, show the definite decrease in fatigue life caused by the mud.

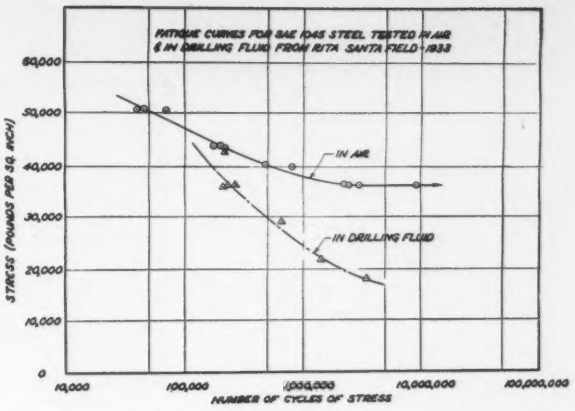


Figure 3

At this time it was recommended that the contractor try the application of a protective coating such as asphalt base paint, or use a zinc wire wrapped around the pipe under the counterbore of the tool joint.

The particular problem in this case was solved by welding the tool joint to the pipe which prevented mud from reaching the threads in the vulnerable zone and also provided added support beyond the threads.

In the presence of corrosive drilling mud the simultaneous action of corrosion and fatigue combine to cause failure in drill stem members which can lead to very expensixe fishing jobs. Generally speaking, the loss of the material which fails is insignificant compared to the loss entailed in fishing operations which may last from a few hours to days or weeks.

Figures 2, 4, 5 and 6 show cross sections of these various drill stem members and the arrows point to zones of greatest vulnerability to corrosive attack and consequently zones where failures due to corrosion fatigue are most likely to occur.

In Figure 4 again, which shows a cross section of a counterbore weld tool joint, the arrow points to the unengaged threads in the bottom of the pipe socket. Although threads are known stress raisers, failures at this location are extremely rare in a non-corrosive environment.

In Figure 5 is shown a shrink type construction with the arrows pointing to the zones at the juncture of the tool joint and pipe. While failures have been known to occur at this location in the absence of corrosion they are infrequent. When corrosive conditions are encountered, this zone is vulnerable to attack because the tool joint prevents the pipe from contacting the hole.

To explain further, the outside of drill stem members which touch or rub the wall of the hole are continually scrubbed and scoured so that corrosive attack is not permitted to become concentrated. In this particular zone, as already mentioned, the tool joint prevents the pipe adjacent to the shoulder from

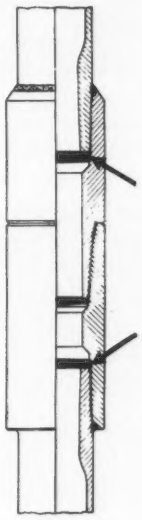


Figure 4

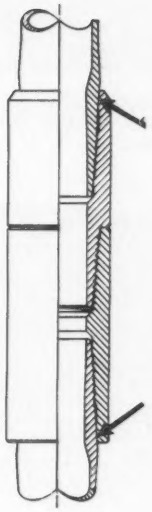


Figure 5

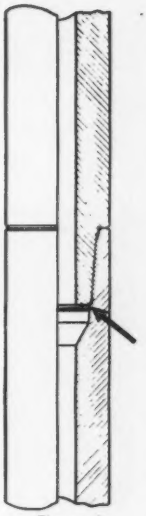


Figure 6

being cleaned by the wall of the hole, thus corrosion at this location can continue unhindered.

Figure 6 shows the unengaged threads in bottom portion of a drill collar box. Failures occur in this location even in the absence of corrosion and under corrosive conditions are accelerated to an extreme degree. Failures in the drill collars are particularly bad both because drill collars are more difficult to fish from the hole than other drill stem members and because the cost per foot of drill collar is high.

It should also be mentioned that fatigue failures occur in the pin members of both tool joints and drill collars. These failures, however, are generally caused by pure fatigue of the notched or threaded members and are seldom if ever influenced by corrosion since these locations are protected from corrosion during operation.

The entire length of the drill pipe both internally and externally is vulnerable to corrosion fatigue, the inside to a greater degree than the outside due to the scrubbing mentioned previously. The full length of the drill stem is mentioned only in passing since this subject has been treated in detail by Battelle

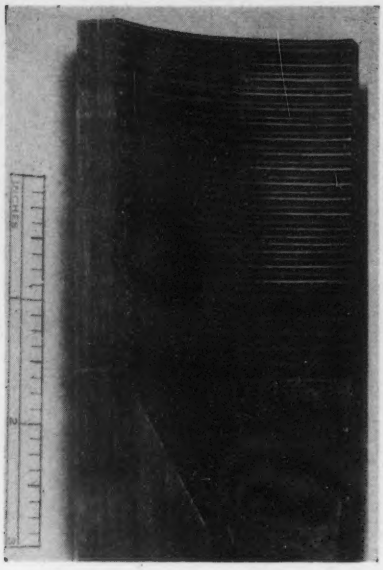


Figure 7—A crack in the unengaged threads in the bottom of the pipe socket on an API pipe end.

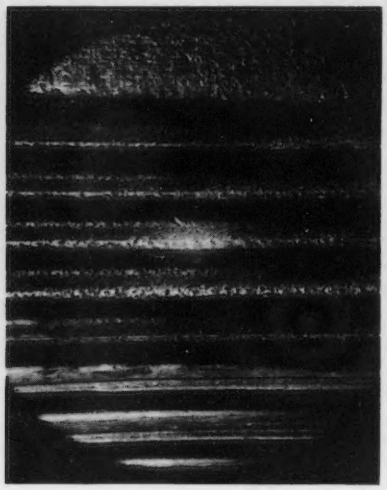


Figure 8—An enlarged view of the zone shown in Figure 7. Note cracks in the first threads and the extensive corrosion.

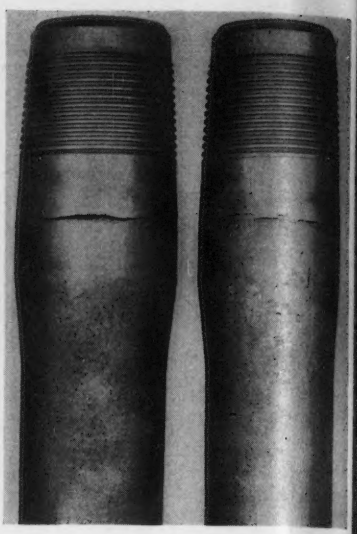


Figure 9—Drill pipe wherein failure has occurred at the final point of contact between pipe and a shrink type tool joint.

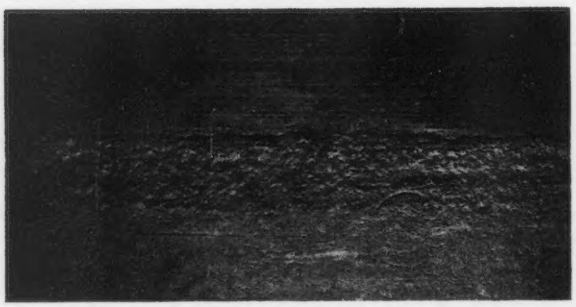


Figure 10—A close-up of a failure similar to that in Figure 9, shows the corroded zone around the failure.

Memorial Institute in a series of articles appearing in **The Drilling Contractor**[2] during 1946 and 1947.

Figures 7 through 14 are views of corroded zones of drill stem members wherein field failure has occurred either in the member shown or in other similar members in the same string.

The joint shown in Figure 7 did not fail. However, failure occurred in the same location on the joint at the opposite end of the pipe. This joint had made approximately 75,000 feet of hole in South Central Kansas. Failures in this location are not common and occur generally only after extended service.

It is possible by frequent, proper inspection to detect cracks in some of the members illustrated before ultimate failure occurs. Fortunately this is especially true of drill collar boxes which cause the greatest amount of trouble. Once the cracks are discovered the question of severity arises.

In an attempt to determine whether the circumferential length of fatigue cracks has any correlation with depth, sections containing various length cracks have been cut from drill collar pins and boxes. These

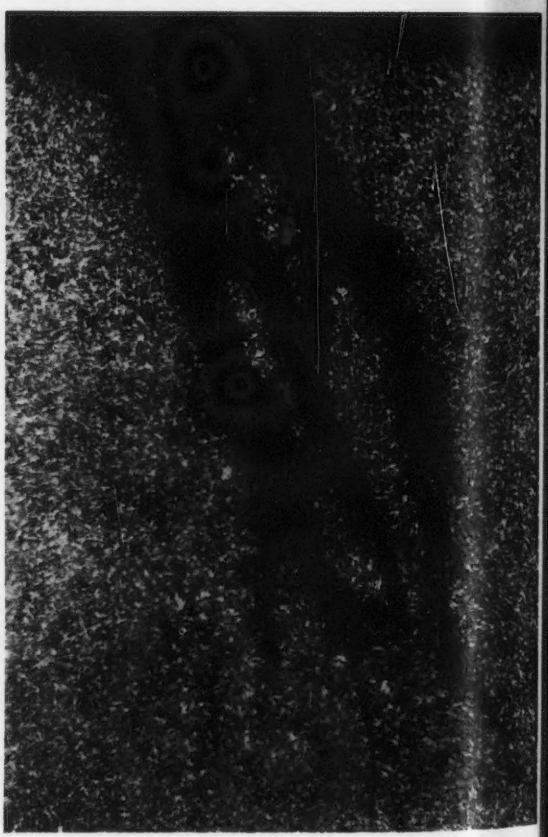


Figure 11—An enlarged view of a sectioned face containing the cracks. Note corrosion products are present at the very bottom of cracks which were approximately 0.040-inch deep.

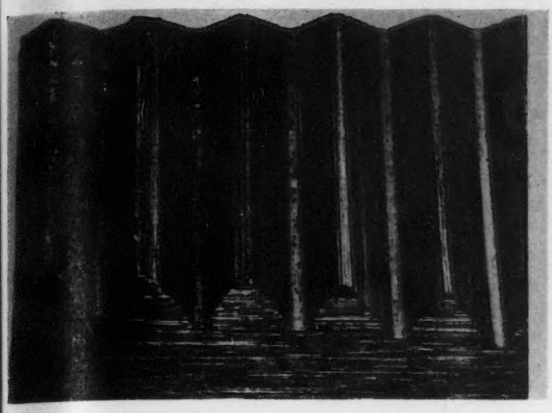


Figure 12—A section from a drill collar box wherein failure has occurred in the unengaged threads at the bottom of the box.

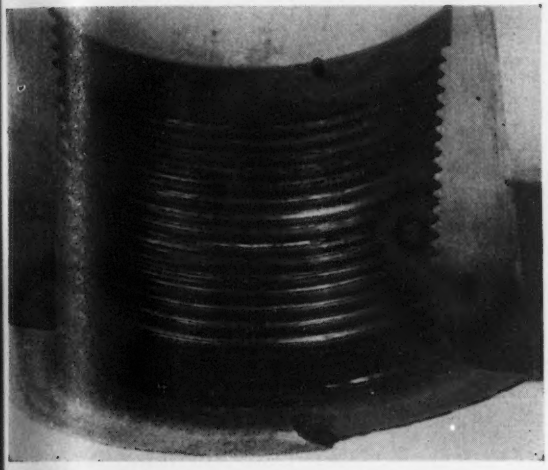


Figure 13—A cross section of a box showing the zone in which corrosion and failure have occurred.

sections were cooled in liquid nitrogen and broken in the plane of the cracks. Figure 14 shows the broken faces of such specimens. Four of these specimens are from cracked pins wherein little or no corrosion was present, the other is from a box which was rather severely corroded. It will be noted in this particular case that the depth of crack for a given surface length is considerably greater on the corroded specimen.

Although no definite conclusions have been drawn it appears that under corrosion fatigue conditions the

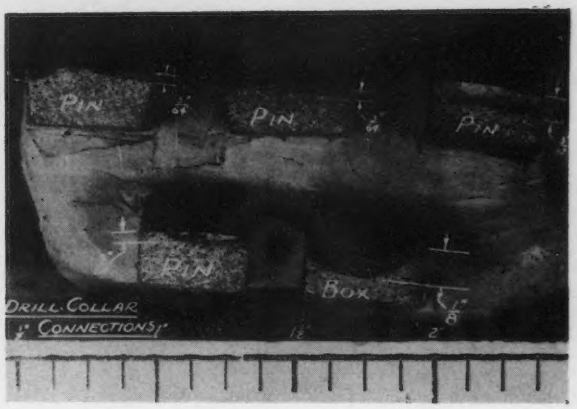


Figure 14

depth of a crack for a given length is primarily dependent on the severity of corrosion.

It should be pointed out that, of the failures discussed, those occurring in drill collar boxes are by far the most frequent and most serious. The other types of failures are actually very infrequent.

The fact that practically all failures of the above types result in fishing jobs poses a very definite problem. It appears these failures might be prevented, or at least considerably reduced, if corrosion of the drill stem could be eliminated.

References

1. Blaine B. Wescott. Fatigue and Corrosion Fatigue of Steel. *Mech. Eng.*, **60**, 813-833, 828 (1938).
2. L. R. Jackson, H. M. Banta and R. C. McMaster. *The Drilling Contractor*, **2**, No. 3, 43-51 (1946) May 15.

   Laboratory Corrosion Fatigue Test of Steels. *idem*, **3**, No. 1, 46-60 (1946) Nov. 15.

   Batelle Report on Field Survey. *idem*, **3**, No. 3, 42-47, 55 (1947) April 15.

   Periodic Cleaning of Drill Pipe. *idem*, **3**, No. 4, 50-53 (1947) June 15.

   L. R. Jackson, R. C. McMaster, H. M. Banta and T. P. Nordin. Use of Sodium Chromate Additions in Drilling Fluids. *idem*, **3**, No. 5, 77-81 (1947) Aug. 15.

   L. R. Jackson, H. M. Banta, R. C. McMaster and J. Bernbaum. Possibilities of Zinc Coatings on Drill Pipe. *idem*, **3**, No. 6, 50-51 (1947) Oct. 15.

   L. R. Jackson, H. M. Banta, R. C. McMaster, T. P. Nordin and G. T. Muehlenkamp. First Progress Report on Non-Destructive Testing of Drill Pipe. *idem*, **4**, No. 1, 54-55, 72 (1947) Dec. 15.

Drill Stem Corrosion in West Texas*

By STANLEY C. MOORE*

Abstract

Each of the 700 or more drilling rigs operating in West Texas has an investment of $30,000 to $70,000 in drill stem and one one drilling company there estimates drill stem costs on each rig to be $137 a day. A large part of the cost is attributed to rapid depreciation of drill stem from corrosion and corrosion fatigue, heavy corrosion from underlying salt strata being the principal culprit. Deeper wells drilled recently have faced an increasing corrosion problem as a result of reduction in salt content of well fluids.

The very costly results of corrosion fatigue failures of drill collar joints is cited, including the numerous operational difficulties resulting from mitigation measures.

Hughes Tool Company first placed cast zinc rings in boxes before the pin was screwed in, thus forcing the ring into place and intimately engaging the unengaged threads at the bottom of the box. These proved unsatisfactory, so magnesium strip was pressed in place in the drill collarbox. Tests of the rings are described. Recent changes in drilling practice have made magnesium rings unsuitable and aluminum rings are being tested.

MR. FARR has reviewed the problem of drill stem corrosion as it affects the drilling industry as a whole.[1] We'd like to bring to you some of our observations of this problem in the Permian Basin area of West Texas and New Mexico.

As you may know, the Permian Basin has been one of the most active areas in the oil drilling and production industries for many years. For the last ten years, approximately one-fourth of all the drilling rigs operating in the United States have been located in the Permian Basin. In the last three years two new oil fields of major proportions have been developed—the Canyon Reef of Scurry, Kent and Borden Counties and the current Spraberry Trend of Midland, Glasscock, Upton and Reagan Counties. The spectacular nature of these developments has caused the real oil news of the Permian Basin to be overlooked. A recent survey showed that there are now 632 recognized oil fields in the Permian Basin—and in the year 1952 there were 252 new oil fields or pay zones discovered in this area. We mention these figures so you may realize the magnitude of the drilling activity in the Permian Basin and so that you may conceive of the economic importance of the drill stem corrosion problem. Each of the 700 or more drilling rigs operating in West Texas has an investment of $30,000 to $70,000 in drill stem. A recent publication of accounting figures of one West Texas drilling company showed their drill stem costs on each rig to be $137.00 per day.

A large portion of this cost may be attributed to rapid depreciation of the drill stem because of corrosion and corrosion fatigue. Much of this corrosion is traceable to a geological condition peculiar to the Permian Basin. Throughout the Basin there is an underlying massive salt strata at depths varying from 1000 to 4000 feet. Any well drilled in the Basin must drill through the salt section and the drilling fluid system becomes contaminated with salt.

Until about 10 years ago, nearly all the wells drilled were relatively shallow, and the wells drilled through the salt section and to total depth with a saturated salt water mud. The high salt concentration approaching saturation was not particularly harmful from a corrosion standpoint.

As wells were drilled deeper in recent years, it became common practice to drill a large diameter hole through the salt zone and set casing to seal off the salt section. The hole was then deepened with smaller diameter bits run down inside this "salt string." The "salt string" was considered necessary because continuous circulation of the drilling fluid through the salt section caused the hole to enlarge in this area resulting in numerous operational troubles.

Although the salt section was sealed off, the mud system was already contaminated by salt. Further in some localities, surface water used for "make up" in the mud system would contain ½ per cent to 1½ per cent salt. As a result of this residual salt, the circulating fluid contained from ½ per cent to 5 per cent salt—a very corrosive fluid.

In the last year of the recent war and the years immediately afterward, deep hole drilling increased rapidly. There was an immediate outbreak of drill stem failures. Operators who were accustomed to obtaining 100,000 feet of hole drilled with a string of drill pipe would have new strings go to pieces after drilling 10,000 to 20,000 feet. The tube mills who manufactured drill pipe were swamped with complaints and in nearly every case their laboratory investigation of samples of the pipe indicated corrosion fatigue was the culprit.

Although there was a tremendous amount of drill pipe failure in the area, the primary concern of our company was with drill collar joint failures. Figure 6 illustrates such a drill collar joint. Note that at the bottom of the female or box member there are several threads which are not covered by the male or pin member. It is necessary to make the pin short in order that it will not strike the bottom of the box before the shoulders can meet. In a properly made up joint, these unengaged threads are at the weakest part of the joint, and consequently at the point of greatest flexure—and greatest stress. Re-

★A paper presented at a meeting of Houston Section, National Association of Corrosion Engineers, March 18, 1952. Submitted for publication March 25, 1952.

* Drill Collar Service Company, Midland, Texas.

peated bending at this point will produce a fatigue failure—and in the presence of a corrosive fluid, the failure occurs much more rapidly.

These box fatigue failures were extremely costly because they were usually undetected until failure occurred in the well during the drilling operation. This required a fishing operation to remove the broken-off string of drill collars, which is always costly. Further, the loss in drill collar length made the failure and repair, by machining a new joint, more costly than is at first apparent. A stand of three 30-foot drill collars is easily handled in the derrick, but when each collar is cut back to 26 feet the stand is only 78 feet long instead of 90 feet and the derrick man can't handle such a short stand. There is no place to rack them in the derrick. As a result, a stub must be welded to the end of the collars to lengthen them, or the collars replaced. Either is a very costly choice.

Drill collar box failures were a real problem in the Scurry County Reef drilling. A typical example is the case of an operator who moved four rigs in from the Rocky Mountain area. He had 20 drill collars in use at each rig. He had never before had any drill collar box failures, although he had had numerous pin failures. Within 60 days after he started operations he had experienced from four to eight box failures on each rig.

The Hughes Tool Company had only recently introduced an improved drill collar joint which ultilized cold worked thread roots to increase the fatigue life of the joint. It helped reduce pin failures, but the corrosion destroyed the cold worked surface in the boxes and box failures continued. It was suggested that localized cathodic protection would protect the unengaged box threads and the field tests were made to test this idea. The first sacrificial anodes were rings of cast zinc placed in the boxes before the pin was screwed in. The zinc rings were pushed in place by the pin and intimately contacted the unengaged threads in the bottom of the box.

These zinc rings proved to be unsatisfactory from an operational standpoint and because of the cost of manufacture.

The next anodes to be tested were rings made from Dow's Galvoline magnesium strip 3/8 inch x 3/4 inch cross section with an iron wire core. This strip could be heated and easily bent into the proper diameter ring and when pressed in place in the drill collar box had enough "spring" action to remain firmly in place. It later proved that as the magnesium was consumed, the iron wire core held the ring in place even though only fragments of magnesium remained.

In the first test, a string of collars were selected in which 10 boxes had been newly machined and the thread roots cold worked. Five of the boxes were protected with magnesium anode rings, five were not. After three wells had been drilled, all five of the unprotected boxes were cracked. When we lost contact with the test after the fifth well was drilled, none of the protected boxes had cracked.

Similar tests were made with other rigs and comparable results were obtained. The use of the magnesium rings became widespread. In this area where without magnesium anode rings the life of a drill collar box is almost surely limited to less than five wells, operators consistently get service of 12 or more wells with boxes properly machined and cold worked and continuously protected by magnesium anode rings.

There has been a recent change in drilling practice in West Texas, which alters the situation. Because of the shortage of steel, the use of a salt string has been discontinued. In all of the Spraberry Trend (and overall about 50 percent of the wells in the Permian Basin) wells are now drilled to a total depth with saturated salt water mud. There is still some corrosion in the drill collar boxes and it would be desirable to use anode rings. However, the magnesium material deteriorates very rapidly in the high salt content mud and use of magnesium anode rings is not practical. We have made some tests using aluminum rings made of 61S alloy in the same string with magnesium anode rings. In one test, the magnesium rings were completely gone after seven days of operation. The aluminum rings were still in good condition after the well was completed—approximately 30 days operation.

Reference

1. A. P. Farr. Evidence of Corrosion Failures in Drill Stem Members. *Corrosion*, **9**, No. 4, 108-111 (1953) April.

Discussion

(The discussion hereunder pertains to both the paper by Mr. Moore, immediately preceding, and that by Mr. Farr beginning on page 108, this issue.)

Discussion by Oliver Osborn, Dow Chemical Company, Freeport, Texas:

I think that Mr. Farr and his co-workers at Hughes Tool are to be commended on the excellent manner in which they have illustrated the processes of corrosion and cathodic protection by color photography.

From the data presented by Mr. Moore, it seems rather conclusive that the presence of a magnesium ring adjacent to the area of greatest fatigue has significantly decreased the incidence of drill collar failure. One of the questions which I am sure will come to mind is "Why?" Is it the cathodic protection afforded by the magnesium that is effective in halting fatigue corrosion, or is the high alkaline environment set up by the solution of the magnesium responsible? Literature references on fatigue corrosion postulate that it is electrochemical in nature by virtue of the fact that metal areas under high stress are anodic to surrounding areas of lower stress and because stress also may cause local rupture in oxide films. Repeated stressing of a drill collar could quite conceivably produce an anodic area at the point of greatest stress which in time would cause sufficient corrosion to result in a crack. Cathodic protection then quite possibly might be used to halt this type of corrosion. The principal

problem would be whether the magnitude of current required for protection would fall within practical limits since it is expected that very high values would be necessary.

Let us return now to the magnesium ring to determine if it is capable of producing these high current density values. If it has a life of one month, calculations show that it will produce densities in the order of 150-200 ma/sq. ft. (assuming that the effective surface area covered is equivalent to four times the area of the magnesium). This value would be considered in the proper range to secure protection under the conditions encountered, and therefore, cathodic protection could conceivably explain the mechanism.

In examining the used rings which Mr. Moore has displayed, however, on some of them it was not apparent where an electrical contact was being established with the collar since they seemed to be covered with a corrosion product on all surfaces. If an electrical contact was not formed, it is obvious that cathodic protection cannot explain the phenomenon and consequently, some other mechanism must be looked for. Under these circumstances it may be that the alkaline environment produced by the corrosion of the magnesium has a protective effect on the stressed area. It is well known that high Ph values (10 or above) reduce the corrosion rate of steel by the formation of protective films of insoluble hydrous ferrous oxide and where calcium and magnesium ions are present in the water, by the formation of insoluble calcium carbonate and magnesium hydroxide films, consequently, the "alkaline environment theory" might also be used to explain the phenomenon. Actually it is quite probable that both mechanisms are simultaneously contributing.

In answer to the question as to why fatigue failures seem to occur more often in brines of lower salinity, it might be that the greater solubility of dissolved oxygen in the lower salinity water is the contributing factor. Or, an anlysis of these low salinity brines might show a lack of corrosion inhibiting anions such as sulfates or carbonates or cations such as magnesium or calcium which are often present in the more concentrated brines.

We have recently had a rather interesting experience which may or may not be related to the problem. An experiment was conducted with three 60-foot steel hull shrimp boats in order to determine the effectiveness of cathodic protection with magnesium anodes. Magnesium was installed on one of the three and after six months of operation the boats were removed from the water for inspection. On the two unprotected boats, which incidentally were heavily rusted, the welded skags which support the propeller shafts were cracked adjacent to the welds, while on the protected boat the skag was intact.

It is going to be very interesting to see what the future holds in the use of cathodic protection to combat fatigue corrosion.

Electrochemical Behavior of Metals As a Basis for the Study of Corrosion*

By R. PIONTELLI*

Abstract

Some general concepts in the study of the electrochemical behavior of metals are introduced.

The experimental arrangements for the determination of polarization diagrams are discussed on the basis of the results obtained working on model cells.

An entirely new type of arrangement is described.

Some typical experimental results are given and some general rules are deduced concerning the electrochemical behavior of metals.

A brief mention is given of the possible relations between this behavior and structural properties of metals and solutions and the passivity problem.

IN THE THEORETICAL study of the following phenomena: corrosion and passivity, inhibition, and certain factors in plating of metals and alloys, wide use is made of hypothetic diagrams of anodic and cathodic polarization overvoltages. The number of those effectively determined, with suitable experimental methods is, however, extremely scarce when one considers only the most important metals, in usual conditions.

Some very valuable information on the electrochemical behavior of metals is given by the study of displacement reactions and of concentration cells, as well as by experiments with radioactive tracers.

The main and more complete source so far is, however, the experimental study of the electromotive behavior of each metal, in absence or in presence of external current.

These remarks will therefore concern: Some concepts, experimental methods and results and some theoretical conclusions in this field, in which the present author and his associates have been actively working for more than 15 years.[1,2] The most general case considered in this study is shown schematically in Figure 1, in which:

M—is the metal to be studied, in the shape of an electrode in contact with a solution S_M, which contains one of its simple salts, and therefore its "solvated" ions M^+_S (supposed to be all of the same valence z);

B—is an auxiliary electrode (plunged in a solution S_B, separated from S_M by a diaphragm), through which we submit M to passage of external current by applying between the terminals B′ and B (which we suppose made of the same metal) a voltage E. The cell: $B/S_B/S_M/M/B'$ is called *"polarization cell."*

N—is a *reference electrode,* the solution S_N of which meets the solution S_M through a capillary tube containing a diaphragm H.

We call the cell: $N'/M/S_M/S_N/N$ (whose terminals are also identical) *"tensiometric cell of the electrode M,"* and the potential difference E_M, measured between N and N′: the *"relative voltage"* of the electrode M with respect to the reference electrode N.

We shall assume E_M as positive when the electric potential of the terminal N′ is higher than that of N. In the practical conditions of corrosion, the laws followed by E_M are complex, and sometimes very puzzling.

The first indispensable step for the interpretation of the results is the determination of the laws of dependence of E_M upon the density of an imposed current under conditions as near as possible to those in which attack reaction occurs where the metal surface is practically uniform, and spontaneous processes are practically absent.

We must therefore consider, first of all, the behavior of electrodes of the metals under examination, in contact with the solutions of their own salts.

We shall now consider only conditions in which the sole processes involving the electrode M are: 1) Exchange of metal ions M^+ on the surface M/S_M[(1)]:

$$M \underset{c}{\overset{a}{\rightleftarrows}} M_S^{z+} + z\,[e]_M$$

Let us now consider the tensiometric cell as a partial system, whose Gibbs free enthalpy is: G_c (in Joules).

In consequence of circulation, through the cell, of an electric charge: $dq = z\,F\,d\xi$ Coulomb

F = 96,500 Coulomb/equiv.;

z = equivalent/unity of ξ[(2)] at constant pressure and temperature, M functioning as the cathode in conditions thermodynamically ideal, let dG_c be the increment of G_c.

$E_{M,g} = -\frac{1}{zF}\frac{dG_c}{d\xi} = -\frac{\Delta G_c}{zF}$ (Volt) is the "ideal relative voltage" of the metal M in respect to the reference electrode.

★ Submitted for publication February 5, 1952.

* Laboratory of Electrochemistry, Chemical Physics and Metallurgy, Institute of Technology, Milan, Italy.

(Superior figures thus,[1] without parentheses, indicate references to be found at the end of this article. Superior figures thus,(2) with parentheses, indicate footnotes to be found at the bottom of the column of type in which the superior figure appears.)

(1) The symbols represent:
M and $[e]_M$: the atom and the electron, respectively, in the lattice of M;
M_S^{z+} the ion in solution;
We shall consider only ions of valency z.
The index $\overset{a}{\rightarrow}$ and $\vec{c}$ represent the directions of reaction, for which the metal M is functioning, respectively, as the anode, or as the cathode.

(2) ξ is the "degree of advancement" of the reactions in the cell.

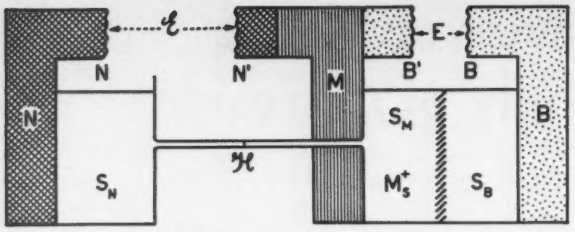


Figure 1—General arrangement for studying the electrochemical behavior of a metal M (schematic).

2) Exchange of electrons at the contact M/N:

$$z\,[e]_M \underset{c}{\overset{a}{\rightleftarrows}} z\,[e]_N \cdot$$

The value E°_M of $E_{M,g}$ in "standard conditions" (for pressure and composition) gives the position of M in the "electrochemical series," or its "nobility degree,"[3] and therefore it is the basis for the definition of the conditions, in which the metal is "thermodynamically stable" against its environment (conditions of "immunity.")[4]

Let us now consider the electrode in a real condition, corresponding however to the absence of external current and again of spontaneous local processes.

From the point of view of values of E_M, in these conditions, and of their constancy and reproducibility, i.e., considering the effective "electromotive behavior" of electrodes in absence of current, metals may be classified as follows.[3]

For some metals (in particular: Pb, Tl, Sn, Cd, Hg), which we call *"normal,"* the values of E_M are constant, reproducible, and relatively little influenced by history of the electrode; and they may in general be considered nearly coincident with $E_{M,g}$.[5]

The behavior of another group of metals (which we call *"intermediate metals"*: Zn, Cu, Ag, Bi, Sb) is also practically normal in the absence of current.[6]

On the contrary, for a group of metals, the "inert metals" (comprising in particular the transition elements: Fe, Co, Ni, etc.), the difference between actual and ideal relative voltages may be high, and is influenced by a large number of circumstances, some of which are accidental.

In order to understand these results, the following considerations seem useful.

Consider the resulting rate of any reaction as difference between the partial rates of opposite processes.

Thus for the density of current $\vec{i}_{M+}$ of anodic dissolution of the metal M (either in consequence of circulation of external currents or of spontaneous reactions), we may write:

$$\vec{i}_{M+} = i_a - i_c \quad (\text{or } \vec{i}_{M+} = i_c - i_a)$$

In the absence of resultant anodic current (that is to say when the net dissolution rate is zero): $i_c = i_a$.

To the common value, i^g, of i_c and i_a, corresponding to any equilibrium condition, we may give the name of "equilibrium exchange density of current."

i_a and i_c (and therefore $\vec{i}_{M+}$) are functions of E_M (i_a increasing, and i_c decreasing as E_M increases).

When E_M is different from $E_{M,g}$, we have therefore a resultant current in the anodic or in the cathodic direction.

On the basis of the preceding results one must apparently admit the existence, for the various metals, of very different ionic exchange rates.

For the interpretation of the fact that, for inert metals, the values of E_M may be appreciably different from $E_{M,g}$, without allowing passage of detectable currents, these metals being thus, in general, very slow or unable, when starting from any accidental condition, to attain the true equilibrium for ionic exchanges, one may admit that the i^g values, and the increments of i_a corresponding to moderate increments of E_M, are low or very low.

This situation may be considered also from another point of view.

Thermodynamically, the difference ΔE_M between the actual value of E_M and the ideal one, may be considered as a measure of the work available for the electrochemical reaction to advance in a corresponding direction.[4]

The ratio $\Delta E_M / i_{M+}$ may therefore be considered as expressing the "equivalent resistance" in the reaction of ionic exchange.

The inert metal may show, therefore, high reaction resistance when ΔE_M is significant in the practical absence of net exchange rate.

When the electrode is subject to passage of external currents (and the density of the resulting current is i_{M+}), one may write:

$$E_M = E_{M,g} + \Delta_i E_M$$

$\Delta_i E_M$ is the "overvoltage" with respect to the ideal conditions.

Considerations on the Experimental Methods of Investigation

We shall now briefly discuss some aspects of the experimental methods we have used in our studies.

(3) Let us indicate with:

$\frac{\Lambda^M}{z}$, $\frac{\Sigma I}{z}$, $\frac{-W_{M^+}}{z}$ the ratios (in Volts) to z, respectively: of the "molar sublimation energy" of the metal, of the total "ionization work" of the atom in the gaseous state; and of the "molar chemical energy of solvation" of the resulting ion. One may write (as a rough approximation)

$$E^\circ_M = \frac{\Lambda^M + \Sigma I - W_{M^+}}{z} + K = \Omega_M + K$$

Ω_M is the so-called *"nobility index"* of M and correlates its nobility with other properties more directly dependent on the atomic structure while the constant K depends in practice only upon the nature of the reference electrode and on physical conditions. One must remember that the values of $-W_{M^+}$ are known only in a relative way, and with poor approximation.

(4) According to one of the propositions recently formulated by the CITCE (Bern Meeting, August, 1951).

(5) The occurrence of local processes (concerning the reduction of H^+, O_2, etc.) may of course vitiate, in practice, also the electromotive behavior of normal metals in contact with solutions of their own salts.

(6) The distinction between intermediate and normal metals may be, however, convenient in consideration of other aspects of electrochemical behavior, in particular when external currents circulate.

considering only the so called "direct method," by which the E_M values are measured (with a potentiometer) or recorded (with a cathode-ray oscillograph, or string galvanometer), while in the polarizing cell either permanent currents or short current pulses are circulating.

In order to reduce to a minimum the causes of error, in the application of the direct method, we have studied, in particular, the characteristics of the cell.[4]

Numerous arrangements were tried. We worked under the following conditions:

a) uniform distribution of current (cylindrical cells, in which the electrode submitted to measurement filled the whole cross-section);

b) careful elimination of the dissolved oxygen (which greatly disturbes the measurements at low current densities), by prolonged bubbling of purified nitrogen, and through preliminary prolonged electrolysis at low current density (which also eliminates possible traces of disturbing impurities); and eventual separation of anodic and cathodic compartments;

c) strong stirring of solution to reduce to a minimum the concentration differences. We have generally accomplished this through swift bubbling of pure nitrogen.[7]

d) careful setting up of the Luggin-Haber capillary tube, whose influence on the measurement of overvoltages is illustrated by Figures 2 to 6 taken from experiments carried out with the aid of R. Aletti and G. Bianchi.[5] These represent the distribution of the equipotential surfaces in cells constituting macroscopic models of those employed in overvoltage measurements.[8] Figures 2 and 3 show this distribution in those cases in which the model of capillary is put in front of the electrode surface at a certain distance from this surface. Figure 2 concerns a condition of very low polarizability of electrode surface (Lead anode in Pb $(NH_2SO_3)_2$ 0.5 moles/1, at a mean current density of 100 A/m^2).

The presence of the capillary changes the distribution of equipotential surfaces, which however, in proximity to the electrode, run parallel to its surface. The potential drop in the limiting layers of solution is therefore uniform.

As the potential "taken up" by the capillary corresponds to a zone in the solution somewhat distant from the electrodes, the voltage measured includes an error "through additional resistance."

Figure 3 concerns a condition of high polarizability

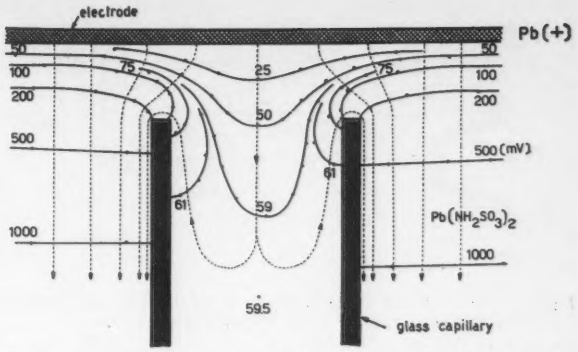


Figure 2—Equipotential curves (full lines) in a model cell (Pb anode, in Pb $(NH_2SO_3)_2$ 0.5 M/1, at 25° C. at 100 A/m^2). Etched lines are current lines.

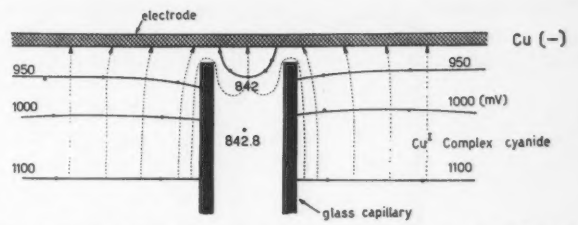


Figure 3—As in Figure 2. (Copper cathode in complex cyanide solution.)

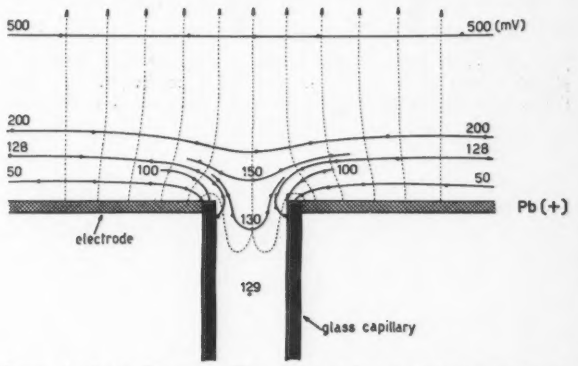


Figure 4—As in Figure 2. (The model of Luggin-Haber's capillary is placed behind and through the perforated electrode.)

(copper cathode in complex cyanide solution). The presence of the capillary is again disturbing the distribution of the equipotential surfaces, but in this case, in a way which renders the voltage drop in the limiting layers not uniform.

Notwithstanding the inclusion of an error through "additional resistance," the voltage existing between metal and adjacent solution layers, in the zone in which the current distribution is not disturbed, is greater than the voltage between metal and solution in the capillary. There is a "screen effect," surpassing, in absolute value, the opposite effect due to "additional resistance."

When the terminal section of the capillary is plane, and pressed against the electrode surface, as in usual practice, the "screen effect" may become very important, but it is very difficult to estimate. We have, therefore, often adopted the arrangement of which Figure 4 gives the principle. With this arrangement one has, practically in any case, only an error by

(7) This method of stirring cannot suffice for prolonged electrolysis when density of current surpasses the order of (2 to 3) $\times 10^{-2}$ A/cm^2. The measurements made with the direct method at higher densities are however not quite reliable in view of changes of the electrode conditions.

(8) For technical details see reference 5. In the case of Figures 2, 4, 6 reference electrode is Pb in the same solution; in that of Figure 3, it is a calomel saturated electrode. It is perhaps superfluous to remark that these results give only a qualitative view of the influence of the position of the capillary in the various conditions, while an orientative evaluation of the quantitative aspects of the question is only obtainable through a careful discussion of various factors (scale of the model; conductance of solution; current density, etc.).

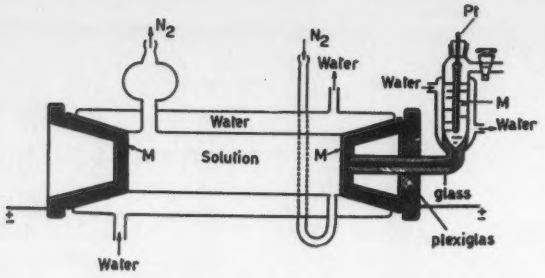


Figure 5—Cell for measurements of metal polarization equivalent to the arrangement of the model cell represented in Figure 4.

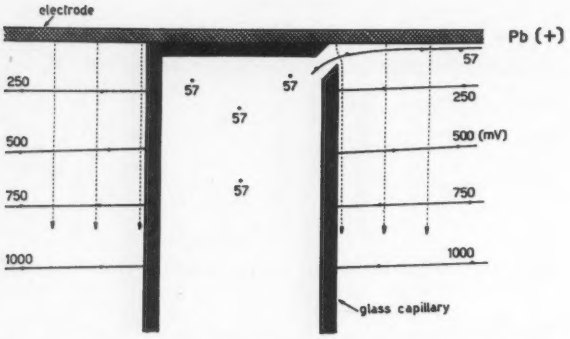


Figure 6—As in Figure 2. The model of Luggin-Haber's capillary is placed in front of the electrode. The front of capillary is closed and the contact with external solution is obtained by means of the small lateral canal.

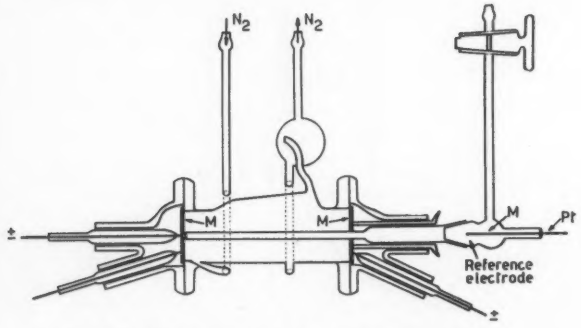


Figure 7—Cell equivalent to the arrangement of Figure 6.

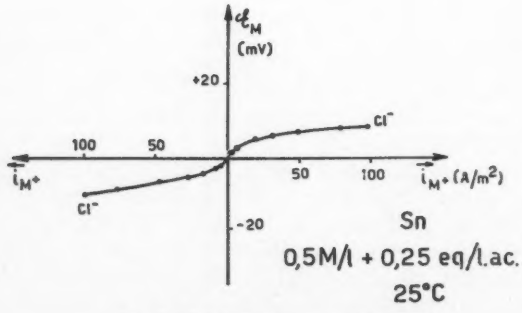


Figure 8—Polarization curves of tin.

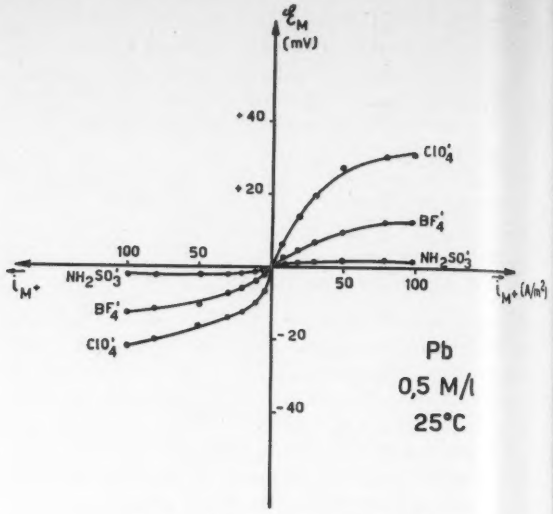


Figure 9—Polarization curves of lead.

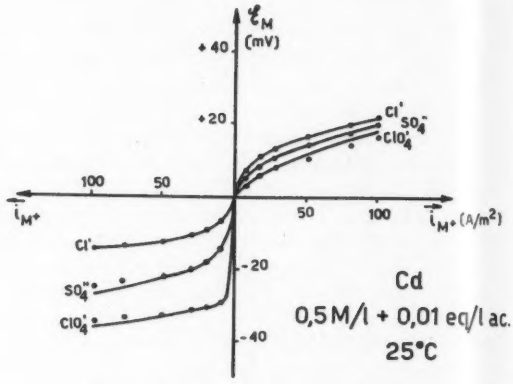


Figure 10—Polarization curves of cadmium.

excess through additional resistance.[9] The order of importance of this error may be estimated (on the basis of the conductance of the solutions and of the results obtained with model cell.)

Figure 5 represents one of our arrangements, consisting only of glass and metal. This cell gives good results (when, also, on the electrode surface, there is a formation of obstructive layers); but it requires great care in arranging the capillary, and makes the use of a perforated electrode necessary. The experiments on models have led to the realization of an entirely new disposition, the principle of which is illustrated in Figure 6. One cell in which this principle is applied (realized with the aid also of U. Bertocci, C. Guerci, G. Serravalle, G. Poli) is shown in Figure 7. Further details are given elsewhere.[5]

The diagrams in Figures 8 to 11 give some examples of "polarization curves" (anodic and cathodic)

(9) In our experiments, the reference electrode was often made of the same metal M as that to be investigated, and prepared in the same manner, and we also had $S_N = S_M$. This arrangement is very simple and avoids any contribution of liquid junction, but it cannot find application with inert metals.

obtained by increasing density of current step by step (experiments with the aid of G. Poli.[6])

From these and from a great series of other experimental results, one may derive the following conclusions:

1. The anodic and cathodic polarization phenomena very often show a tendency to be symmetric, in the sense that when a metal shows a high cathodic overvoltage, the anodic one is also high, and vice-versa.[10] The metals with high overvoltages are metals for which also the electrochemical behavior in absence of external current is anomalous and not reproducible (that is to say they are "inert metals"), and vice-versa the metals with very low or low overvoltages are normal or intermediate metals in their electromotive behavior. The intermediate metals sometimes present rather distinct asymmetries (for instance the overvoltages of Zn, are markedly higher on the cathodic side than on the anodic, at parity of any other condition);

2. The electrochemical inertness tends to vanish for sufficient temperature increments.

3. In each limiting class (comprising metals of very different nobility), the various metals present other strong analogies in their electrochemical, behavior, especially on the following points:

   a) In typical structures of the cathodic deposits (which tend to be macrocrystalline for normal and for some of the intermediate metals and microcrystalline for inert metals);
   b) In hydrogen overvoltage: which is high for normal metals (unable to function as hydrogen electrodes and moreover lacking of any catalytic activity in hydrogenation reactions); while, on the contrary, it is low for inert metals (which are good hydrogen electrodes and catalysts);
   c) In aptitude to form amalgams (high for normal and some intermediate metals, and very low for the inert ones); and in polarographic behavior (in general "reversible" for normal and irreversible for inert metals);
   d) In agreement between position in the electrochemical series and behavior in displacement reactions.

      In these, normal metals present a very regular behavior and can also give "autodisplacement phenomena."[11] On the contrary inert metals behave as more noble than indicated by $E°_M$, when displacing others; while, when being displaced, they behave as less noble metals;
   e) In concentration cells, which are very active for normal metals, and for some intermediate ones, and inactive for the inert ones.[5]

4. In each class, one may observe a graduation of properties for the various metals. In the series: Fe, Co, Ni, it is Ni which presents the maximum inertness, while in the group: Ru, Rh, Pd, the last seems less inert (at least in the anodic direction).

5. In the series: Ag, Cu, Au, Ag is practically normal, Cu is not so normal, while Au is nearly inert.

   In the series: Bi, Sb, As, Bi is also practically normal, Sb less, while As is entirely inert (but with some very different characteristics from those of transition metals).

   This increase of inertness is thus parallel to that of metalloidic character and to the decrease of interatomic distances in the lattice.

   The cause of this behavior could "a priori" be sought:

   a) In structural properties of the metallic and liquid phases;
   b) In the structure of the interphase zone;
   c) In superficial conditions of the metal.

We have now rather conclusive evidence that inert metals always encounter high overvoltages in their deposition on any cathodic material (which may vary from the mercury in the polarograph, to the same metals).

On the other hand deposition of some normal and intermediate metals on inert cathodes is possible with rather low overvoltages.

Inert metals may finally be used, as inert electrodes, for oxidation and reduction processes, in some of which they certainly exchange electrons with the solution, though without important overvoltages.

It seems therefore reasonable to conclude that surface conditions of inert metals are not the **sole** cause of their inertness.

We shall therefore look for a possible reason of this behavior also in structural properties of the phases.

Experience shows, as particularly important, for the electrochemical inertness of metals:

1. The existence of an incomplete electronic subshell "d", in the "free atom;"
2. High values of "chemical heat" and entropy of solvation of ions;
3. Low values of interatomic distances in lattice.

The Nernst theory gives, for the phenomena at metal/solutions interfaces, a picture essentially based on the analogy with the phenomena at liquid/vapor interface.

After such observations, a more complicated conception should be thought of.

The exchange processes of ions (or electrons), between a metal and an electrolytic solution, are comparable to a heterogeneous reaction between metal lattice and solution.

Any single reaction of this sort also represents an exchange of electric charge between the phases, and it is therefore influenced by electric fields (natural or applied), in addition to the influence exerted (as for any reaction) by temperature and composition.

In these reactions, solvent molecules and anions may be regarded as amongst the reacting substances or, also, as a sort of catalyst (or, on the contrary, as an inhibitor).

The intrinsic rate of these reactions and, therefore,

---

(10) There are some important exceptions to this rule; in particular in presence of hydrolysis. Of course, passivity phenomena can also give very clear asymmetries; another cause of which is interference with other electrode processes.

(11) Lead (when very pure) gives in the $Pb(NO_3)_2$ solutions "Saturn trees," the formation of which may be very rapid,[7] thus demonstrating practical absence of polarization phenomena in the ionic exchange processes and in those of crystal growth.

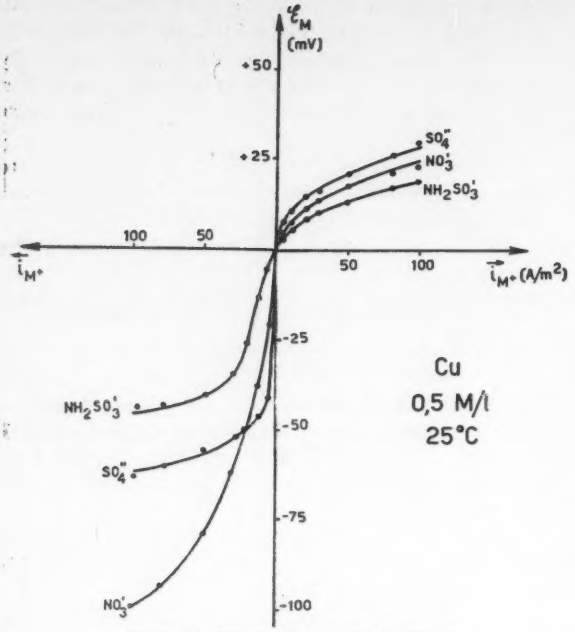


Figure 11—Polarization curves of copper.

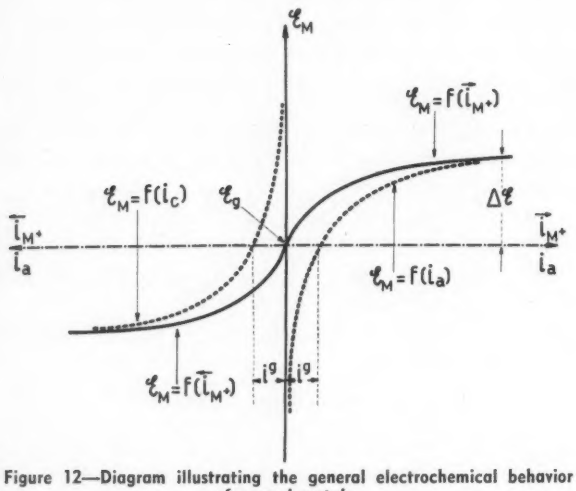


Figure 12—Diagram illustrating the general electrochemical behavior of normal metals.

the requirements of electric activation, depend, first of all, on structural properties of the two reacting phases and in particular on bond conditions of the ions in both.

The inert metals are characterized (from the physico-chemical point of view) by high melting and boiling points, strong mechanical resistance, short lattice distances, etc.

This behavior has suggested some theoretical attempts, and in particular that by Pauling,[9] which, in agreement with magnetic and chemical properties, admits the existence in the lattice of interionic covalent bonds in resonance amongst the possible configurations.

Independently of the possibility of finding a basis for explaining the electrochemical behavior, in any of the actually proposed theories of the metallic state,

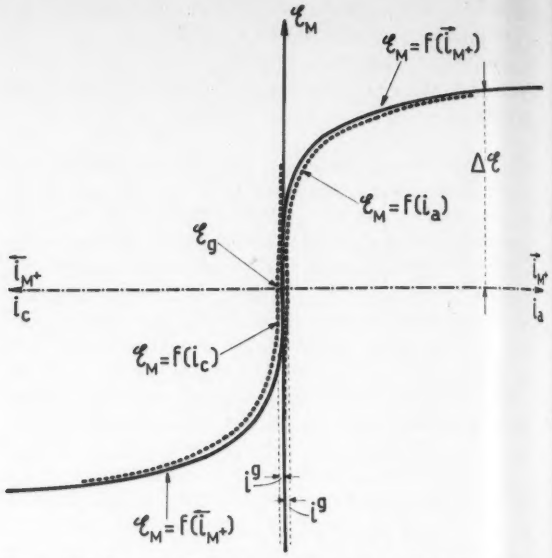


Figure 13—Diagram illustrating the general electrochemical behavior of inert metals.

one may admit that the mentioned physico-chemical and electrochemical properties are concordant in indicating the exceptional strength of the bonds acting on the ions in the lattice of inert metals.

On the other hand, well known properties (optical, magnetic, chemical) of the dissolved ions of transition metals suggests again the existence of a bond condition affecting the electronic subshells of these ions.

One may therefore advance the following simplified picture of the ionic exchange processes:

In the case of normal metals, the transition from the bond condition in the lattice to that in solution (or vice-versa) does not imply passage through configurations of high chemical potential energy.

The exchange currents: anodic i_a, and cathodic i_c, are strong likewise in absence of imposed electric fields, and therefore in the equilibrium condition too (see Figure 12).

The existing data indicate, for instance, for normal metals (at 25 degrees C and in 0.5 M solutions of their simple salts) values of i^g (as deduced from reasonable kinetic hypotheses), in the range from 10^{-3} to 1 A/cm² or still higher.

The application of very small polarizing voltages is thus sufficient for producing strong resultant densities of current (either in the anodic or in the cathodic direction).

In the case of inert metals, on the contrary, the nature of their ionic bonds in the two phases implies, in the exchange processes, passage through configurations corresponding to pronounced maxima for the chemical potential energy.

The existence of high overvoltages, and the possibility of great deviations from the ideal condition, also in absence of net current, can thus find a basis of explanation (Figure 13).

The order of influence of anions tends to be sym-

metric, in the sense that it is analogous in anodic and in cathodic processes (Figures 9 to 12).

This order is that corresponding to the influence of these anions in many homogenous reactions and in exchange processes between metals and solutions, studied by the method of radioactive tracers.[10]

In the majority of cases, to Cl^- (and also to Br^- and I^-) correspond the minimum overvoltages (low in any case); and, on the contrary, to ClO^-_4 the maximum ones,[12] while other inorganic anions occupy intermediate positions.

The course of electrode processes could be "a priori" influenced by anions through:

a) Structure and bond state of metal ions in the solution;
b) Structure of the interphase zone;
c) Superficial conditions of electrode.

As for what concerns the first point, excluding cases of formation of stable complexes, the influence of the anion does not show any clear correlation either with the values of the "ionic strength," or with those of the ionic activities of the M^+s.

In other words, if there is a kinetic influence of the anion through the bond conditions of metal ions in solution, the cause must be sought outside the inter-ionic attractions considered in the Debye-Hückel theory.

This influence seems, on the contrary, to be correlated in some cases, with structural properties of the "interphase," or with conditions of electrode surface, or with the structure of the aquocomplexes formed by the solvated metal ion, but more generally, it seems to be comparable with a catalytic influence of the anion on ionic exchange processes.

It seems, moreover, to be essentially determined by the "deformability" of the anion under the influence of electric fields.

The possible reasons of these results have been discussed elsewhere.[10]

Surface Conditions, Electrochemical Behavior and Passivity

While the preceding remarks show the possibility of finding, in structural properties of the two reacting phases, a basis for explaining the general lines of the electrochemical behavior of metals, this does not of course signify that surface conditions of metals have a secondary influence. Following the point of view here developed, superficial conditions of metal and structure of the interphase zone have a fundamental importance as controlling the intimacy of the interaction of the phases in electrochemical reactions.

These conditions become, generally, decisive for the appearance of passivity.

What are the possible relations between electrochemical inertia and passivity?

The answer depends on the definition one gives of the "states of passivity."

In the opinion of the author,[4, 11] in order to include passivity conditions both when the electrode is functioning as anode in polarization cells and when it is submitted to spontaneous attack processes, a rather satisfactory definition could be given on the basis of the "equivalent resistance of reaction" in the process of dissolution in normal ionic form.

This equivalent resistance could be deduced from the mean anodic current density $\vec{i}_{M^+}$ and the difference ΔE_M between the relative voltage and the ideal value $E_{M,g}$ corresponding to the conditions considered. One could therefore define the passivity states as those in which this resistance (referred to the unit of apparent electrode surface) is over a conventional limit (for instance of the order of 50 Ω cm^2); or those in which, in addition to a resistance above this conventional limit, $\vec{i}_{M^+}$ is inferior to another conventional limit for instance 10^{-5} A/cm^2); or ΔE_M is over another limit (of the order of 0.3 to 0.5 Volt).

To circumscribe the field of the passivity conditions, one could finally adopt limiting values both of $\vec{i}_{M^+}$ and ΔE_M.

The relation between inertia and passivity is different, according to the definition chosen.

One could, for instance, admit the existence of passivity conditions "by inertia."

In the general case, it seems very difficult either to explain all the aspects of inertia (even for the anodic direction of the processes) on the sole basis of an habitual condition of passivity, through obstructive films or layers or to consider passivity as a simple consequence of intrinsic inertia.

It is, however, very convincing to suppose that electrochemical inertia is the ideal foundation on which every form of passivity can establish itself.

In fact inertia involves high overvoltages in consequence of rather low current densities and, therefore, it allows processes, corresponding to nobler electrode voltages, to interfere or substitute themselves for the metal dissolution process, thus permitting a more or less abrupt change of surface conditions and hence producing passivation through any possible mechanism.

The simple presence of films of adsorbed substances implies a rather long series of significant consequences for the kinetics of ionic exchange processes: Steric hindrance (between the reacting particles: superficial atoms in lattice, and solvent molecules, or anions); changes in distribution of electric field; changes in bond conditions of the superficial metal atoms.

The consequences depend, of course, on: Degree of completion of films; nature of adsorptive bonds, interatomic distances in lattice, etc.

Experiments give evidence in the sense that, for normal metals, eventual presence of adsorption films does not increase, in a very significant measure, the resistances in the reaction of exchange of ions.

For normal and some intermediate metals, only formation of obstructive layers, compact and impervious enough, may lead to conditions corresponding to all the requirements of a definition of passivity.

But for inert metals, on the contrary, all these requirements are probably attainable simply through a physical adsorption of oxygen.

The influence of anions in passivity is very often

(12) In mixed solutions, the activating influence of Cl^- may overwhelm the action of ClO_4.[10]

supposed to depend only on solubility of corrosion products or on "penetration power" of anions in eventual obstructive layers.

The results quoted above (and some others) show the good parallelism existing between catalytic power of the anion on ionic exchanges, and their activating power in passivity phenomena in presence of obstructive layers.

It is a convincing hypothesis that the aptitude of anions to gather together in the interphase (deriving in particular from low hydration and effective radius, and high deformability), is effective also in the destruction of adsorption films, or in the penetration in covering layers.

To complete the study of the aspects of electrochemical behavior intervening in corrosion phenomena, one must consider the behavior of the various metals as cathodes in reduction processes, and in particular the overvoltages in the reactions:

$$2\,H^{+}_{aq} + 2[e]_{M} \rightarrow H_2$$

or:

$$O_2 + 2\,H_2O + 4[e]_{M} \rightarrow 4\,OH^{-}_{aq}$$

and so on.

The experimental study of hydrogen overvoltages is in a relatively advanced situation. On the contrary the reduction processes of oxygen have up to now been little studied,[13] in spite of their great significance in the field of corrosion.

Only diffusion problems are usually considered for this purpose, and a current opinion is that their kinetics do not depend upon the nature of the cathode.

The result obtained ten years ago by the author and G. Poli[18] give, however, a clear indication that this is untrue. Work also is now being done in this laboratory in this field.

(13) A very important exception is given by the beautiful polarographic studies by P. Van Rysselberghe and his associates.[12]

Conclusion

The natural, complete and, finally, the shortest, way to study corrosion phenomena, as well as any other aspect of applied electrochemistry of metals, is to make fundamental researches on their general electrochemical behavior.

References

1. Proceedings of the 2nd Meeting (Milan 1950) International Committee of Electrochemical Thermodynamics and Kinetics (CITCE); Milan 1951, p. 79, 136, 149, 163, 185, 344, 379 (papers containing detailed references to previous work).
2. R. Piontelli. *J. Instit. Metals*, **80**, 99 (1951-52).
3. See 1. p. 163 and R. Piontelli. Colloque International sur la liaison Chimique (Paris 1948) p. 102; *Journal de Chimie Phys.*, **45**, 115 (1948); **46**, 288 (1949); *Z. f. Elektrochemie*, **55**, 128 (1951).
4. R. Piontelli. Proceedings of the Third Meeting (Bern 1951) of CITCE, Milan 1952 in print.
5. R. Piontelli—G. Bianchi. See 1. p. 379; R. Piontelli—G. Bianchi—R. Aletti. *Z. Elektrochem.* in print.
6. R. Piontelli—G. Poli. See 1. p. 136.
7. R. Piontelli—L. Canonica. *Gazz. Chim. Ital.*, 78, 599, 606 (1948).
8. R. Piontelli—M. Simonetta. *Gazz. Chim. Ital.*, **78**, 424, 430, 614, 697, (1948); **79**, 24, 716 (1949); **80**, 189 (1950).
9. L. Pauling. *Phys. Rev.*, **54**, 899 (1938); The Nature of Chemical Bond, New York 1940.
10. R. Piontelli. See 1 p. 185.
11. R. Piontelli. *Werkstoffe u. Korrosion*, in print.
12. P. Van Rysselberghe. See 1 p. 42, 160, 287.
13. R. Piontelli—G. Poli. *Mem. R. Accad. Italia*, 13, 903 (1942).

The Corrosion Engineer Uses Plastics*

By FRANK L. WHITNEY, JR.*

Abstract

Continued progress in the development and improvements in the properties of plastics places these materials high on the materials of construction lists for the corrosion engineer to consider. To achieve maximum performance and economy in their use—what they are, what their chemical and physical limitations are and how they are best applied and installed must be known. An attempt is made to simplify the task of acquiring general knowledge of the plastics by dividing into three major groups and thirteen "families." Factors to be considered in order to obtain good performance are presented. These include effect of composition, when to use thick and thin films, importance of surface preparation, testing procedures and design and economics. The effects of polymerization, the use of modifiers, plasticizers, pigments and binders are briefly discussed in relation to corrosion resistance and physical properties. Some "do's and don'ts" on the use of thin and thick films are outlined and illustrated. If more adequate testing procedures are employed, considerable time and money can be saved; a brief outline of some of the more important features are mentioned. Design is important to good performance, whether the plastic is used as a coating, a lining, or a solid installation.

Introduction

OVER the past several years a great deal of information has been published concerning plastics, particularly concerning their use as a medium for the protection of metals against corrosion and as a substitute for metals and alloys. It is probably true that consideration of plastics to combat corrosion attained significance and importance as a result of the critical shortages of metals and alloys which existed during World War II and which exist as a result of present conditions of unrest. Nevertheless, improvements in the physical properties, application, maintenance problems and corrosion resistance of these materials have today, it is believed, placed them high on the list of materials for corrosion engineers to consider.

Their use has expanded greatly from the coatings field. Plastics cast, molded, or extruded to produce pipe, tubes, valves and fittings are common. More intricate shapes are now available, ranging from tiny moisture-proof parts for electronic equipment to large processing and distillation equipment. The superior physical and chemical properties of the resin cements make it possible for them to replace the standard ceramic cements in many instances. Thus it can be said they have assumed a position in the corrosion field equal in stature to the metals and alloys and to the other nonmetallics. This subject, naturally, is a tremendously broad one; and in the time allotted for this paper, only the most meager number of highlights can be touched upon. It is necessary, therefore, to limit the scope of treatment to that designed to increase fundamental knowledge of the subject, rather than to attempt to provide specific information on the materials available, their application, their corrosion resistance in various environments and their maintenance. It is dangerous to generalize but to illustrate points, this has been done. This should be kept in mind because notable exceptions to conclusions in the following discussion no doubt will be found.

Although some 300 coatings have been evaluated by the writer such evaluations were concerned largely with maintenance paints and with drum linings to prevent product contamination. In a more indirect fashion, some experience has been gained with linings and solid products. The writer's work and experience in this connection have been confined largely to the study of application, surface preparation and design requirements necessary for good performance, assuming, of course, that the material is inert to the chemical environment.

Definition and Function of Plastics

To insure a proper foundation on the subject, perhaps a definition of plastics is desirable. Plastics are organic materials derived from synthetic resins, natural resins, cellulose derivatives, coal tar, petroleum or protein substances compounded to give specific useful characteristics and advantages for structural and chemical services.[1] Tator has indicated that plastic materials have two strong appeals —they are simple to apply and the protection mechanism is understandable and predictable.[2] If simplicity in application refers to the physical aspects alone, then possibly they may be considered simple to apply; but if simplicity refers to the considerations which must be given to the variable factors of preparation, particularly in the field, to achieve a successful application, then they may not, perhaps, be considered simple to apply.[3] That the protection mechanism is understandable and predictable may also be open to question. If it is meant that the protection mechanism is understandable and predictable from a functional standpoint only, this statement then may hold. For, briefly, organic materials function in corrosion protection as an inert barrier between the corrosive environment and the metal subject to corrosion.[4] Such organic materials may also act as electrical insulating barriers against galvanic circuits arising from couples of dissimilar metals or stray currents.[4] To infer, however, that

*A paper presented at a meeting of South Central Region, National Association of Corrosion Engineers, New Orleans, La., October 1-3, 1952.

*Monsanto Chemical Company, St. Louis.

the protection mechanism is understandable and predictable when considering a specific plastic for a specific environment without prior knowledge or experience of performance may be highly questionable. The selection of plastics should be given the same consideration as the selection of metals and alloys.

If application is simple and performance predictable, there have been too many coating and lining applications which have failed unnecessarily. Possibly, in the majority of the cases the cause was a lack of knowledge of the performance and limitations of the organic materials. Possibly, it was due to improper or inadequate testing of the material in question. Possibly it was due to a failure to apply properly or to take time to think the job through and to secure adequate and competent counseling on the particular problem.

Essential Knowledge Required for the Successful Selection of Plastics

Based upon the writer's experience in the evaluation and performance of plastic coatings, linings and solid products in the field and a study of the comments and recommended practices outlined by the specialists in this field, there are definite things that should be done and should not be done to obtain satisfactory service. These might be established as rules to follow, except that the word "rule" implies a certain degree of inflexibility. In this particular endeavor, with the numerous variables to be encountered, it is difficult to foresee any inflexible rule from which there can be no deviation. Rather, these things may be called *factors to be considered.* Presentation of these factors is the principal objective of this paper.

There will be many who are experienced in this connection who may listen to or read this paper and to whom the information will no doubt be "old hat." This paper is not for them, it could be maintained. The writer will not take this position but rather will suggest that time be taken to reflect—to look around and see how many errors in application have been committed, how many times consideration of all aspects which lead to the most satisfactory performance has been neglected. This is the challenge to the reader. The knowledge exists, but it is not being used in fields where results count! The job is still unfinished until knowledge has been put to use in every case. These factors are recommended for serious consideration when selecting materials for specific services. If they are adhered to quite likely the experience of failures from improper selection and application can be avoided. These may be outlined as follows:

1) What the material is
2) Methods of identification
3) Effects of constituents
4) The use of thin films
5) Surface preparation
6) Testing procedures
7) Design and economics

1. *What Is It?*

To make an intelligent selection of a material for evaluation it must be known. There are today many hundreds, perhaps even thousands, of protective coatings, linings and molded plastics listed under various trade names. If selection on the basis of individual products is attempted, selection would be complex and difficult. Yet, the writer believes it is possible to divide the plastics into groups and families which will simplify to a great extent selection of various materials for use or test. Nevertheless what the material is, must be known or at least to what group or family it belongs must be determined, so its general performance characteristics can be calculated. Thus, one may be able to judge for himself its value in relation to similar products and to products of other classifications or families. Even if the salesman will not, or cannot, tell what type of material is being offered, data supplied concerning its use will disclose its nature. Each organic material has identifying resistances and characteristics. The details by which the groups and families of products may be identified are reviewed later.

2. *Identification*

If doubt continues regarding identity of the material based on its corrosion and physical characteristics, there are standard physical test procedures by which it may be identified by general type. The tests include combustion, flame color and odor determinations. These methods of identification are available in the published literature, plastics handbooks, and materials engineering manuals. A typical and representative identification procedure was recently published in a booklet by the *Materials and Methods Magazine*[5].

3. *Effects of Constituents*

Generally speaking, the most chemically resistant material is the "pure" product completely polymerized. Unfortunately, the physical characteristics of most resins in this state are often undesirable and limit useful application in the field. Therefore, these materials are modified, or plasticized, to obtain improved physical, storage and handling properties. But, in so doing, the effect in some cases is to lower the corrosion resistance of the material. Thus, when information is given that a resin or plastic is modified, or plasticized, or treated in some other way for specific purposes, it may be assumed its maximum corrosion performance is affected as compared to a "pure" product.

a. Polymerization

Polymerization may be effected by heat or the use of catalysts. Resins handled in this fashion may be expected to have good corrosion resistance for the environments in which they are applicable, but are generally brittle and may have other limiting physical properties. Examples are the baked phenolics and the catalyzed furanes.

b. Modifiers and Plasticizers

Organic materials when modified, plasticized, or treated with anti-oxidants, accelerators, etc., will have greater flexibility, ductility, adhesion, abrasion resistance, age resistance, etc. These desirable characteristics are sometimes achieved at a sacrifice of corrosion resistance. Yet, the mechanical improvement often outweighs the loss in corrosion resistance by extending the over-all service life in spite of lowered corrosion resistance. For example, drums coated with a baked phenolic resin to prevent contamination of a white product cracked and caused rust spots to develop upon a single handling because of the brittleness of the coating. Modifying the coating to produce a flexible film less susceptible to fracture gave a service of several handlings. Yet, laboratory test data showed that the pure baked phenolic was superior in corrosion resistance to the flexible phenolic film.

c. Pigmentation

In addition to promoting light stability, pigments are often added to plastics, particularly coatings, to give color to satisfy the aesthetic sense. Pigmentation may also reduce corrosion resistance because it produces a discontinuous film and provides an easier path for penetration. Further, the pigment itself may not be inert to the environment. The more inert pigments which provide color variations are carbon, titanium dioxide, green chrome oxide, chrome yellow, silicon oxides, red lead, zinc chromate, etc. Pigments having inferior corrosion resistance to many environments are the white leads, sulfates, iron oxides, metallic pigments such as aluminum, bronze, or stainless steel flakes and pigments which derive their color from organic dyes, etc.

d. Binders, Fillers, Laminants, Etc.

In some cases the use of binders, particularly in molded or cast plastics, has a deleterious effect on general performance in severe corrosion service. For example, laminants of cotton, linen, paper, or other materials susceptible to chemical attack should not be used in critical environments, for attack can proceed along the path of the binding or filler material. This action usually results in swelling, flaking, spalling or cracking. Plastics using binders of carbon, acid-leached asbestos, blue African asbestos, silicon oxides, etc. may be satisfactorily used with maximum resistance in any environment for which the plastic is suitable.

4. The Use of Thin Films

If a rule were to be adopted, the writer believes it might be: Avoid thin films! Practically all plastics can be formulated so they may be applied in films of varying thicknesses. Correlation of laboratory and field test data with actual field performance indicates that the use of thin films represents possibly the most common misunderstanding in the use of organic materials. The writer notes that Tator also subscribes to this point of view.[2] Thin films are cheap. And because a material may have been found

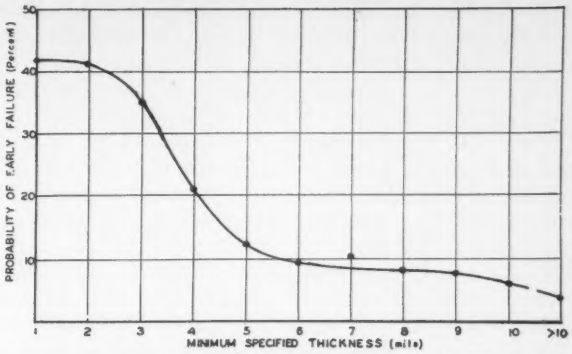


Figure 1—Probability of early paint failure. Five to six mil thickness is indicated as a minimum to reduce probability of early paint failure.[7]

resistant to a specific corrosive, it is assumed that a thin film gives adequate protection. This is erroneous!

It must be remembered that thin films are susceptible to unavoidable imperfections in the coating application which usually will expose the base metal. The more coats employed and the thicker the application, the less susceptibility to continuous imperfections, and therefore greater protection is achieved.[2, 6] In addition, it should be remembered that even if a perfect coating application were achieved, coatings and linings are susceptible to accident or mechanical injury. It is obvious that the thicker and more resilient the film, the less susceptible it is to physical damage.

This does not mean, of course, that thin films may not be used. They are generally suitable in mildly corrosive environments, usually as maintenance paints, or as linings to prevent product contamination. They may also be employed in combination with inhibitors and cathodic protection. In severe chemical environments, however, and where mechanical damage, conditions of stress, and agitation are to be experienced, the writer believes a lining thickness of less than ⅛ inch should never be used. What is meant by a severe chemical environment? It is suggested that processes requiring the austenitic stainless steels and other highly alloyed and expensive materials indicate a severe environment. If these materials are to be replaced with protected steel, then definitely a heavy lining is required.

Quite probably one of the major fields of use for organic coatings is maintenance painting. Opinions may vary widely concerning the minumum thickness of such paint films. Possibly this is due to the degree of severity of exposure. Nevertheless, reputable sources report that, physically speaking, a 5-6 mil thickness is the minimum to achieve a low early failure probability.[7] Figure 1 portrays the percent of early failure versus film thickness.

There is a second rule that might be adopted in the use of thin films which the writer considers important and to which he believes too little attention is given. It is suggested: Never use a thin film over a base metal which in itself has no corrosion resistance to the environment. A coating failure, whether by holidays, mechanical injury or chemical penetration will generally cause the base

metal to become highly anodic. Accelerated corrosion of the base metal may thus occur in localized areas, resulting in rapid perforation of the metal wall.

To illustrate, take the following example. Assume employment of ducts fabricated of Hastelloy B to handle an off-gas containing dilute aqueous hydrochloric acid at ambient temperature. After several years of economic service, the system requires replacement, but due to allocation of this material for defense purposes, it is not available. As a replacement a protective coating suitable to the hydrochloric acid environment applied over steel should not be considered though admittedly the first cost is low. Rather, Monel which would have a reasonable life in the HCl environment, and with its life extended by a protective coating is an indicated substitute.

Possibly this philosophy may best be defined as taking a calculated risk. To illustrate, the Hastelloy B installation costs approximately $6.00 per square foot of surface. (The figures shown here are for illustration only.) A steel installation would cost approximately $1.50 per square foot for the steel, plus $.50 per square foot for the protective coating, giving a total cost of approximately $2.00 per square foot. Although the material cost of Monel is approximately four times that of steel, the installed cost in this case is only about $3.00 per square foot, which together with the $.50 per square foot for the protective coating gives a total cost of approximately $3.50 per square foot. Using the service life of Hastelloy B as a control point, one may calculate the expected life of a steel and a Monel installation, assuming perforation of the coating, and thereby determine which would be the more attractive risk. The study does not end here. Performance records should be established so that practical information is obtained on the service life of such installations. When sufficient performance data have been obtained over a wide variety of conditions, statistical analyses should indicate the most attractive procedures to be investigated, evaluated, or actually put into use when similar problems arise elsewhere.

A third rule believed important in connection with thin films might also be considered. It has to do with coating failures, and is: Do not condemn a coating until the cause of failure has been thoroughly analyzed. If the failure is chemical in nature, generally speaking, the material may be dismissed from use. If, however, failure is due to application, perforation, or mechanical injury, do not discard the material. Rather, study methods of application and design by which the coating may be made to give a satisfactory performance. This attitude, of course, presumes that inertness of the organic barrier to the chemical environment has been predetermined. In many cases, however, such studies lead to rather involved application procedures, which are undesirable because the practical and economic aspects cannot be neglected. Often, however, such evaluations will point the way to alternate methods or materials.

5. *Surface Preparation*

The lack of, inadequate, or improper surface preparation is another major cause for poor performance of organic coatings. This subject alone could be dealt with as a major treatise,[9, 10] but it will not be discussed here. Caution must be exercised concerning the use of so-called simple methods of metal pretreatment. Certain of these measures were investigated and it was found that in severe chemical plant environments they offered little or no advantage over standard systems. In many mild environments, or under conditions where the corrosion or rust on steel, for example, is tightly adherent and of small volume, they may have an economic advantage over such methods of surface preparation as sand or shot blasting, acid washing, etc. Nevertheless, in the severe environments and where practical, it is considered that grit or sand blasting followed by the proper inhibitive primers is the best way to insure good coating performance by preventing underfilm deterioration. In many cases, the writer believes, it necessary to "tailor make" a system to meet the needs of inhibition, adhesion, temperature resistance and impermeability. Compton has indicated that this approach is desirable and necessary, particularly with respect to specific requirements.[11]

6. *Testing Procedures*

Those who have been concerned essentially with testing and evaluation of metals and alloys realize the complexity of the problem. Equivalent complexity may not be found in organic materials, but both have a common denominator. Whatever testing procedures are employed must be reconciled to practical applications in the field and this makes the testing of organic materials no simpler. Weight loss determinations as a measure of corrosion rate may have little significance in assaying performance of organic coatings. Attention is, however, directed to observation of the physical condition of exposed materials. Examination includes such factors as softening, cracking, solvent action, swelling, spalling, shredding, etc. All these observations give clues to the serviceability in the particular environment. However, as with the metals and alloys, actual field experience correlated with these observations is necessary to develop the best interpretation of behavior.

a. Laboratory and Field Testing

Laboratory tests usings perfectly prepared panels are useful for "screening" various materials in relation to chemical inertness. The results, if successful, will not determine performance as applied under field conditions. While the use of vendors' samples, which are ideally prepared, is satisfactory for this type of work, they should not be used to interpret performance in the plant or field.

It is generally observed that more indicative test results are obtained when panels are prepared by the tester following the instructions provided by

the vendor. Application should be made on panels containing welds, sharp corners and other surface irregularities which are representative of the conditions to be met in the field. These are the points which are susceptible to early failure, not the smooth surface upon which an ideal application is more readily obtained.

The question is frequently asked, "How long a test is necessary to evaluate an organic coating?" This is a difficult question to answer and there is no general rule. It may be pointed out, however, that short-time tests are of little value, except when negative; i.e., when such coatings indicate failure. Discussions of the subject with the experts generally indicate an exposure period of from three to six months as necessary to give a reasonable indication of field performance. This is particularly true in the case of the heavy linings and solid plastics. Perhaps the most effective testing in the field is by actual application of the organic material on certain sections, or as portions of the equipment concerned, applied and installed under actual field conditions. Panel tests should be conducted in the field only where equipment location and size prevent any other reasonable method or type of test from being conducted, or unless it is for the purpose of screening several types of coatings and the exposure conditions cannot be duplicated in the laboratory.

One of the most recent and interesting developments in the evaluation of maintenance painting systemsis the KTA Method, developed by Kenneth Tator, Kenneth Tator Associates, Coraopolis, Pennsylvania. Two recent publications, one by Tator[8] and one by Pierce,[7] describe the method and some results obtained with its use. To the writer the method has five strong appeals:

1) It uses a panel which incorporates the major surface conditions which can cause early paint failure, thus approximating better the actual field applications.

2) The panel seems to achieve reproducible results.

3) Performance comparisons may be determined by an arithmetic procedure, which reduces the common errors of human judgment and results in a more accurate evaluation.

4) The procedure is comparatively simple and may be passed on from investigator to investigator without too great a danger in a change of the "yardstick" and a resultant loss in accuracy of any evaluation program.

5) The data to date indicate a marked reduction in testing time to obtain reliable results.

Monsanto Chemical Company's Nitro, West Virginia, plant has contracted for this service. Although the program is only in its infancy, physical appearance of the panels has already indicated the value of the method in comparing various paint systems. Some of Monsanto's other plants are contemplating the use of this method.

Figure 2 illustrates the test panel employed in the KTA Method. It will be observed that all the common surface imperfections are present which contribute to early film failure.

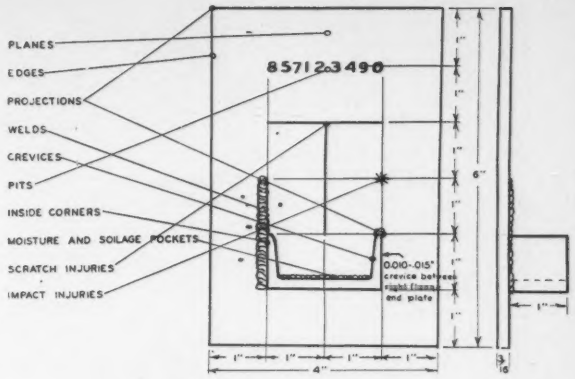


Figure 2—Sketch of KTA test panel.[16]

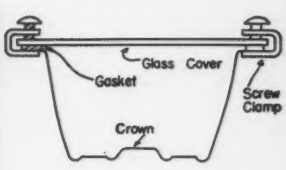


Figure 4—Steel test cup.

Figure 3—Test panel showing early film failure at sharp edges and other surface irregularities.[16]

Figure 3 is an actual test panel which illustrates film failure along sharp edges, welds and other surface irregularities. The smooth portion of the panel, it will be observed, has not yet shown failure.

The cup test is another type of laboratory test incorporating to some degree the conditions to be met in actual practice which tend to promote early failure. General design is shown in Figure 4, but the bottom grooves are accentuated for purposes of illustration. The writer used this type of test some years ago in connection with the evaluation of internal drum coatings. He does not, however, recall the source of supply of this cup. The interior surface of the cup is coated and dried or cured. The cup is then half-filled with the chemicals concerned. After observing the performance of various organic films with this procedure, the writer concluded that this type of test also may be used for other screening evaluations involving tanks, reaction vessels, etc.

It will be noted that the design of this cup provides areas where excessively thin and thick films can occur. Thin spots can occur at the radius of the top flange and at the crown in the bottom of the cup. Thick films can collect in the bottom radius adjacent to the wall and in the radius adjacent to the crown. The excessively thin film is susceptible to perfora-

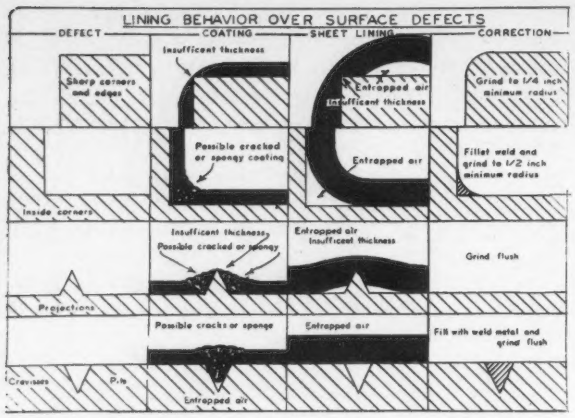


Figure 5—Surface defects and their correction.[16]

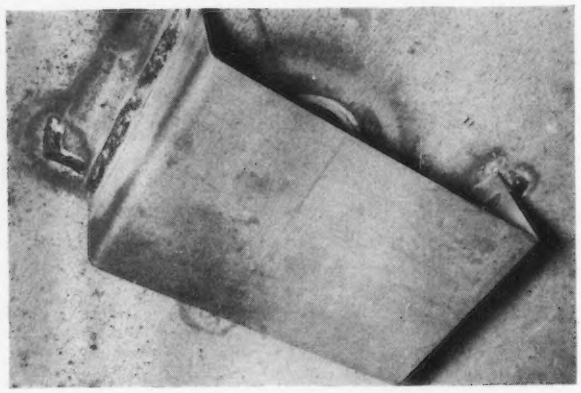


Figure 6—Baffle plate presents a difficult coating and lining problem.[16]

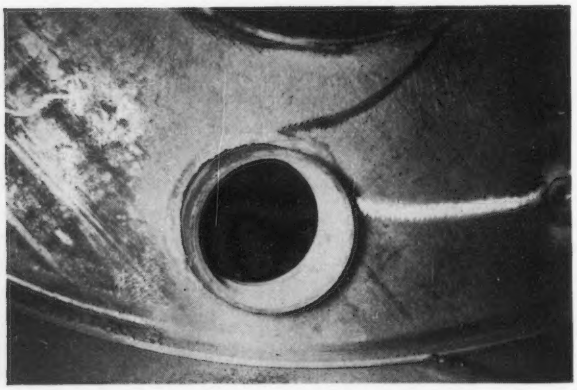


Figure 7—A typical design objectionable from the standpoint of good coating and lining performance.[16]

tion, holidays, dirt and other imperfections, while the excessively thick film in the bottom generally is inferior in corrosion resistance due to incomplete drying or curing.

A third condition also encountered in the field occurs at flanges and other gasketed connections. At this point, abrasion and chemical concentration changes often accelerate attack. This test method is also generally more helpful than the simple panel test when studying the effect of attack in the vapor phase, liquid-vapor interface and liquid phase at elevated temperatures. Transfer of heat through a coated wall has a greater effect on coating performance than immersion at temperature. The cups may be readily installed in ovens or steam baths and the effect of any phase change can be readily observed. The glass top may act as a condenser; thus plant conditions experienced in reactors, storage tanks, etc., are somewhat reproduced.

b. Testing Imperviousness

It is, of course, desirable to employ coatings and linings which are as free from holidays and other imperfections as possible. There are many practical electrical and chemical tests which may be employed to denote porosity or coating weaknesses. The simplest indicator may consist of no more than a probe, a series of dry cells, and an indicating galvanometer. One of the more common errors in testing a coating for porosity is the use of too heavy an electrical discharge. Actual coating perforations in many instances are created in this manner. An intelligent use of such equipment is essential. Depending upon the variety of coating problems on any particular plant, it is suggested that performance standards may be established for the evaluation of porosity with the various types of materials and the various thicknesses employed.

c. Statistics

Another important aspect in the testing of plastics is that of statistical analysis. Those not in the manufacturing field probably do not devote a sufficient amount of time and thought to this aspect. If the magnitude of the problem warrants, statistical analysis probably should be employed to determine the number of tests, where, how, etc., to be conducted in order to differentiate performance in relation to chance and significant variance. Unfortunately this treatment may not be practical in most field studies. The method should be valuable, for example, in maintenance painting studies, small parts coating studies, as in electrical, radio and telephone equipment and in drum and can lining studies.

Design and Economics

Thus far there has been discussed to a large extent the surface conditions of equipment which will promote early coating and lining failures. Design and fabrication changes are required to improve performance. A summary of certain of these defects and their corrections are shown in Figure 5.

Coating and lining applications also are made difficult by odd shapes and protuberances, such as boltings, nozzles, baffles, stiffeners, supports, etc. Typical objectionable designs are shown in Figures 6 and 7. Coating old vessels with design features such as these is difficult. Consideration must be given to the economics of coating "as is," employing the proper design changes to present a smooth surface and replacement. The writer believes that, in general, it will be found profitable to make the design changes to obtain better performance over coating "as is."

Whether it is economical to do this rather than select alternate materials or replace in kind may be determined only by comparing the annual cost of the existing vessel with the expected annual cost of the alternate construction.

When designing new equipment for lining or coating, all features should be incorporated which will provide a smooth surface to obtain best adhesion to insure the best coating performance. Again, economics should tell how far to go in this respect. For example, there are several lining materials which exhibit good chemical resistance, but which have poor adhesion. Many ingenious designs have been developed to mechanically support such linings, even under appreciable differences of thermal expansion. The fact that these designs may be costly must not be overlooked in evaluating probable service life. It may be cheaper in the long run to use ceramic linings or fairly expensive metals and alloys.

Many plastics have undesirable physical properties at low and elevated temperatures. Proper design and installation often will permit these organic materials to be satisfactorily used in spite of their limited physical properties. Other objections have centered around limited fabrication and maintenance. These problems are rapidly being overcome. For example, the rigid polyvinyl chlorides are available in almost any form of pipe, fitting, valve, sheet, etc. They can be joined by welding in a manner similar to metals. This simplifies and reduces cost of fabrications such as duct work and tank linings. Welding also greatly enhances and simplifies maintenance in the field. In a like manner, certain vinyl chloride copolymers, the polyethylenes and the acrylic resins are finding expanded and useful service. With *all* these materials, a careful study of design and installation will generally result in better performance and greater economy.

Identifying or Selecting the Plastic

It was mentioned previously that to make an intelligent selection of a plastic an adequate working knowledge of its properties and performance data must be had. There have been many publications listing the plastic materials according to families, types, classes and other characteristics; some have gone into considerable detail, others have attempted to simplify the problem of classification. The writer believes the problem may be simplified by segregating plastics into three major groups and dividing each group into the more common types of materials as related possibly to the chemical, petroleum, refinery and allied industries. The organization presented may perhaps be arbitrary, but it is offered with the hope it will help orient thinking in the acquisition of knowledge as simply as possible. Furthermore, it is pointed out that none of these groups, or classes, include all available materials for use in these industries. In many instances well-known plastics normally used in the decorative field may find specific application in the chemical and allied industries. The characteristics of the materials outlined in the following are not, of course, complete nor should they be construed solely as a guide to selection. They are presented to assist in identification.

The three major groups are the elastomers, the thermosetting materials and the thermoplastic materials. They are described as follows:

Group I—The Elastomers (1, 2, 3, 5, 12)

In this group maybe included the natural and synthetic rubbers. The most common properties associated with this group of materials may perhaps be related to their elasticity, resiliency and extensibility.

The principal materials which fall into this group are natural rubber; the butadiene-styrene copolymers, commonly identified as Buna S or GR-S; the chlorobutadiene polymers, commonly known as neoprene or GR-M; the butadiene-acrylonitrile polymers, commonly known as Buna N or GR-N; and the iso-butylene copolymers, commonly referred to as the butyl rubbers or GR-I.

Of the elastomers, natural rubber has perhaps the best physical properties. Natural rubber also adheres readily to metals and fabrics and resists abrasion, weak acids and vegetable oils. The natural rubbers, however, are limited in use in the chemical field because of poor resistance to heat, oxidation, sunlight, gasoline and other solvents, lubricating oils, fats and aging. It is in these latter items that the synthetic elastomers generally show their superiority over natural rubber, even if they may not measure up to natural rubber in all the other properties.

Technical data indicate that the styrene rubbers are not oil-resistant, but do have good resistance to abrasion, general chemicals such as acids and alkalies and also exhibit good electrical properties. In the acid field they are satisfactory, except in strong oxidizing acids such as nitric and chromic acids. They may be satisfactorily used in all inorganic salt solutions, except those which are strongly oxidizing. They are satisfactorily used in plating solutions; the inorganic bases, such as sodium hydroxide; pickling solutions; chlorine water; and hypochlorite solutions.

The chlorobutadiene polymers, neoprene, have resistance superior to natural rubber in oils, heat, oxygen, sunlight, flexing life and gas diffusion. Generally speaking, they may find satisfactory use in contact with inorganic chemicals and even strong alkalies. Mineral acids cause deterioration when used in concentrations above 50 percent continuously. However, many applications in concentrations above this range under intermittent exposure conditions have been satisfactory. Strong oxidizing acids, such as concentrated nitric and chromic acids, should be avoided. Use in aqueous halogens is questionable; but where dilute gas and aqueous solutions are experienced, satisfactory use has been reported. These polymers will resist most organic compounds, but the more highly saturated compounds have less effect than the less saturated compounds. The chlorinated hydrocarbons and creosote have an adverse effect

on these polymers. Certain aromatic solvents, such as benzol, cause rapid swelling.

The butadiene-acrylonitrile polymers, Buna N or GR-N, have two outstanding properties. These are resistant to the aromatic solvents and resistant to heat.

The butyl rubbers, or GR-I, have one unique property, which is their resistance to oxidizers, particularly nitric acid. Practically all the other rubbers, synthetic and natural, have poor resistance to this chemical.

Group II—The Thermosetting Materials (1, 2, 3, 5, 6, 12, 13, 14)

This group comprises the phenolics and the furanes. The outstanding characteristics of these materials are heat resistance, low moisture absorption, low coefficient of expansion and maximum dimensional stability. These latter features result in a good resistance to rapid and appreciable temperature changes. Used continuously, the maximum temperature these materials may withstand is in the order of 350 degrees F. They are resistant to salt solutions, practically all acids, halogen gases, sulfur dioxide and organic solvents. They are not resistant to strong oxidizing agents. The alkali resistance of the phenolics is poor while that of the furanes is good, and this perhaps is the major difference by which the two classes may be identified.

Group III—The Thermoplastic Materials (1, 2, 3, 5, 6, 12, 13, 14, 15)

It is in this class that the majority of plastics fall. They differ from the thermosetting materials in that they are not permanently hardened by heat. Although there are many different families in this group, they can perhaps, by common usage be limited to six. These are the bitumins, the vinyls, the polystyrenes, the polyethylenes, the acrylics and the silicones.

The oldest and best known materials are the bitumins, asphalt or coal tar materials. Their distinguishing characteristic lies in their moisture-proofness derived chiefly through thick films. They may be distinguished further by the fact that they are applied hot in many instances and harden upon cooling. There are, however, several emulsions and other formulations which are air-drying.

Possibly the largest family of thermoplastic materials in use today in the chemical, petroleum and allied industries is the vinyls. These may be divided into six classifications which include vinylidene chloride, polyvinyl butyral, polyvinyl alcohol, vinyl chloride copolymer, polyvinyl chloride and polyvinyl acetate. These materials do not have good heat resistance—their maximum useful temperature is around 150 degrees F.

They provide tough elastic-like films. All classes have good resistance to acids, alkalies, oxidizing conditions and age well. Polyvinyl butyral is an exception, for it is slightly attacked by acids and alkalies. Polyvinyl butyral, polyvinyl copolymers and polyvinyl chloride are attacked by solvents. A major limitation in their use has been poor adhesion. However, recent advances in primer formulations provide improved adhesion and now permit these films to be used quite successfully in the field. These wash primers generally consist of phosphoric acid-zinc chromate and a vinyl vehicle. Generally speaking, the vinyl systems should be engineered to fit the specific job. Possibly the necessity for using the wash primer previously mentioned may be considered another characteristic of the vinyl systems.

The polystyrenes (not including the rubbers) have essentially no water absorption and are unaffected by aqueous solutions of salts, acids and alkalies. They are soluble in coal tar hydrocarbons, chlorinated hydrocarbons and esters. As a coating, they lose many of their good properties—have high moisture vapor transmission rates, craze upon drying and age poorly. There are, the writer understands, newer film formulations being produced which do not have these objectionable characteristics. It is believed these formulations include such materials as the styrenated alkyd resins.

The polyethylenes generally have poor heat resistance and soften around the boiling point of water. They have good resistance to acids, oxidizing agents and alkalies, but are attacked by oils and certain organic solvents. They have good impact but poor abrasion resistance. The materials have found some application by flame spraying. A notable exception is, however, polytetraflouroethylene or the flouroethylenes, which have excellent resistance to temperatures up to 620 degrees F. These materials are also extremely inert chemically to most conditions. Their principal limitation is poor physical properties and they are not yet too successful as coatings. Sheet linings have been attempted, but they still are not too practical. At present their chief use is as gaskets, tubing, packings, valve trims, etc.

The acrylic resins, particularly the rigid type, have good resistance to acids and alkalies, except the oxidizing acids, such as nitric and chromic. They also find excellent application in plating solutions at temperatures around 140 degrees F. One grade has been developed which will withstand a temperature of 212 degrees F. Films of the acrylic resins and their copolymers have been manufactured, but their usefulness has not been in the chemical field. They are used largely for decorative purposes.

Another useful group of materials receiving considerable attention is the silicone resins. Certain of these materials have the outstanding characteristic of high heat resistance. Data indicate they will provide protection at temperatures up to 600 degrees F. It is reported that pigmented silicones have withstood temperatures as high as 1000 degrees F for several hours. Silicone resin films do not appear to have any particular outstanding chemical resistance; their chief value seems to lie in weathering resistance, and they are used chiefly for decorative purposes. The silicone rubbers are, however, finding increased use in gasket and packing materials.

There are, of course, other classes in the thermo-

plastic group, including the celluloses, the polyamides, the caseins, the alkyds and glyptals. These materials have not been overlooked, but because at present their specific value lies chiefly in fields other than chemical, they were not included. The phenolic, alkyd, and glyptal resins as paint finishes are well-known for their toughness and excellent atmospheric resistance. A number of the cellulose polyamides and caseins do find specific application in the chemical and petroleum industries.

Acknowledgement

The author appreciates the assistance of Kenneth Tator in supplying material for the illustration of this paper. Appreciation is extended to the following for their helpful comments and courteous review of this paper:

C. P. Dillon, Corrosion Engineer, Carbide & Carbon Chemicals Division, Texas City, Texas.

M. G. Fontana, Chairman, Department of Metallurgy, The Ohio State University, Columbus 10, Ohio.

E. G. Holm, Chief Chemist, Tube-Kote, Inc., Houston 25, Texas.

R. B. Seymour, Executive Vice-President and Technical Director, The Atlas Mineral Products Co., Mertztown, Pennsylvania.

Kenneth Tator, Kenneth Tator Associates, Coraopolis, Pennsylvania.

References

1. H. H. Uhlig. Corrosion Handbook.
2. K. Tator. *Chem. Eng.*, **57**, No. 3, 223-226 (1950) Mar.
3. B. Thomas. Non-Metallic Lining Materials for Process Vessels in the Pulp and Paper Industry. *Corrosion*, **6**, No. 3, 82-87 (1950) Mar.
4. K. Tator. Organic Linings for Chemical Equipment. *Corrosion*, **5**, No. 2, 55-58 (1949) Feb.
5. Materials Engineering File Facts, p 57.
6. G. W. Seagren. Organic Coatings for Corrosion Protection. *Corrosion*, **4**, No. 5, 219-226 (1948) May.
7. Robert R. Pierce. *Chem. Eng.*, **59**, No. 5, 149-153 (1952) May.
8. K. Tator. *Chem. Eng.*, **58**, No. 11, 140-142 (1951) Oct.
9. A. J. Liebman. Surface Preparation Values and Sandblasting Economics. *Corrosion*, **6**, No. 5, 151-157 (1950) May.
10. G. R. Hoover. Preparation of Metal Surfaces for Organic Coating. *Corrosion*, **4**, No. 8, 399-412 (1948) Aug.
11. K. G. Compton. Building Organic Protective Coatings to Special Requirements. *Corrosion*, **5**, No. 5, 148-150 (1949) May.
12. M. G. Fontana. *Trans. AIChE*, **42**, No. 4, 359-377 (1946) Apr.
13. C. G. Munger. Plastic Coatings and Corrosion. *Corrosion*, **4**, No. 11, 557-565 (1948) Nov.
14. J. L. Robertson. *Oil and Gas J.*, **46**, No. 5, 72-78 (1948) May.
15. J. W. Shackleton. Plastics for Corrosion Control. *Corrosion*, **4**, No. 4, 172-178 (1948) Apr.
16. Photographs courtesy Kenneth Tator Associates, Coraopolis, Pa.

ERRATA

Corrosion and Related Problems in Sea-Water Cooland and Pipe Systems in H. M. Ships. *Corrosion*, **8**, No. 12, 417-429 (1952) Dec.

Page 417, for the author line immediately below the title substitute the following:

By I. G. SLATER,[1] L. KENWORTHY[2] and R. MAY[3]

Correcting the spelling of the name Kenworthy.

Aluminum Alloys for Offshore Pipe Lines by Edward T. Wanderer and Donald O. Sprowls. *Corrosion*, **8**, No. 7, 227-233 (1952) July.

Discussion, February, 1953, Page 76-77: The table on Page 76 should replace one at the end of the article on Page 77. The table at the end of the article on Page 77 should replace one on Page 76.

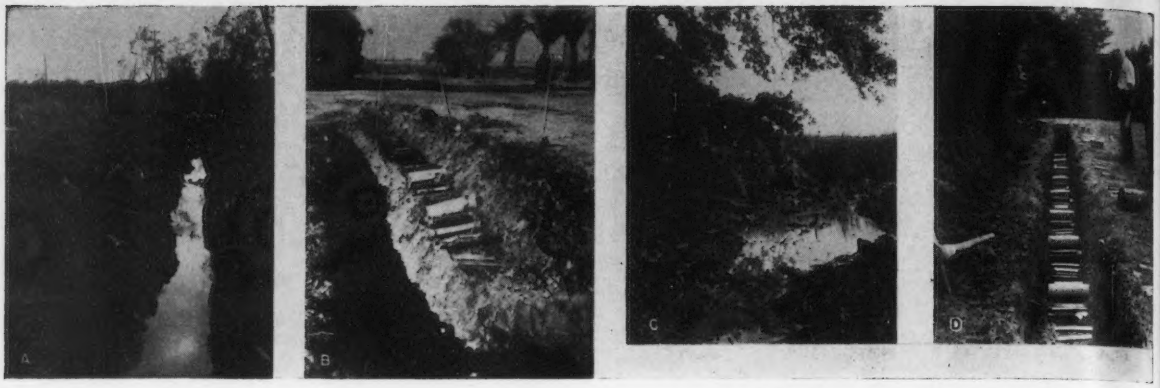


Figure 1—Environmental conditions at Typical test sites. A—Site 56, Lake Charles clay at El Vista, Texas. B—Site 70, Merced silt loam at Buttonwillow, Cal. C—Site 63, tidal marsh at Charleston, S. C. D—Site 55, Hagerstown loam at Loch Raven, Md.

Corrosion of Galvanized Steel In Soils*

By IRVING A. DENISON* and MELVIN ROMANOFF*

Abstract

The results of measurements of the corrosion of galvanized steel and of bare steel and zinc as reference materials after exposure to different soil conditions for a maximum of 13 years are reported. The magnitude and progress of corrosion of galvanized steel as determined by weight loss and pitting is interpreted in terms of the environmental conditions to which the specimens were exposed. From analysis of data on the corrosion of galvanized specimens having different weights of coating, minimum coating requirements for different environmental conditions are suggested.

1. Introduction

IN ORDER to evaluate the effectiveness of zinc coatings in protecting iron and steel from corrosion underground, test specimens of iron and steel coated with different thicknesses of zinc, applied by the hot-dip process, were included in the extensive field-exposure tests undertaken by the National Bureau of Standards in 1924. The thinner coatings did not prevent corrosion in the more corrosive soils, but coatings having a nominal weight of 3 oz/ft² of exposed surface prevented the development of measurable pits on the specimens at all but one of the 47 test sites for the entire period of exposure.[1, 2] Although the sites represented a wide range of soil conditions, it was considered desirable to expose specimens with the heavier zinc coatings to additional soil environments in which some dominant corrosive factor, such as chloride content, acidity, etc., was the apparent cause of corrosion. Accordingly, specimens having the same nominal weight of coating, namely, 3 oz/ft² of surface were buried at 15 additional sites in 1937. A sufficient number of specimens of galvanized steel and of the reference materials, steel and zinc, were buried to provide for removal of two specimens of each material after each of five periods of exposure. This paper deals with the condition of the specimens of the three materials exposed for different periods up to 13 years.

2. Properties of the Soils at the Test Sites

The test sites represent a wide range of environmental conditions with respect to both the chemical and physical properties of the soils (Table I). For example, the hydrogen-ion concentration of the soils ranges from pH 2.6 to 9.4, and the resistivity from 62 to 17,800 ohm-cm. At several of the test sites the soils are highly oxidized to considerable depths, whereas in others the permanent water table is close to the surface. The environmental conditions at several of the test sites are illustrated in Figure 1.

3. Materials

The galvanized and bare steel specimens were 14-inch (35-cm) lengths of pipe 1.5 inches (3.8 cm) in diameter cut from the same lots of commercial materials. The nominal weight of the zinc coating on the galvanized specimens was 3.08 oz/ft.²* The impurities in the spelter in percent were: Al, 0.008; Fe, 0.07; and Pb, 0.78. The steel, both galvanized and bare, was AISI No. B1010, with the nominal composition in percent as follows: C, 0.13 max; Mn, 0.30 to 0.60; P, 0.07 to 0.12; S, 0.06 max. The interior of the specimens was coated with heavy grease, and the ends were closed in order to prevent internal corrosion.

The zinc specimens were plates having the dimensions 12 in. (30.5 cm) by 2.3 in. (5.8 cm) by 0.15 in. (0.4 cm). The impurities determined in the zinc in percent were: Fe, 0.009; Pb, 0.095; Cd, 0.0038.

★ Reprinted from *J. Res. Nat. Bur. Standards*, **49**, No. 5, 299-314 (1952) Nov. Research Paper 2366.

* National Bureau of Standards, Washington, D. C.

* This is the weight of coating on one side of the pipe. Each ounce per square foot of coating is equivalent to 0.00172-inch in thickness.

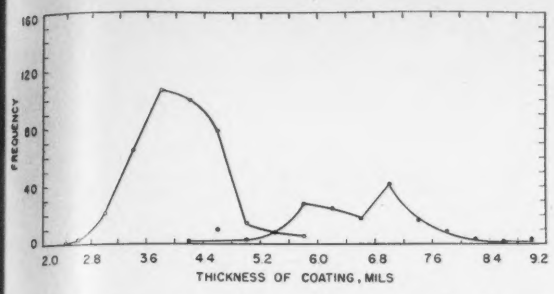


Figure 2—Distribution of coating on specimens. ● Specimen A, length 14 inches. number of observations 389. ○ Specimen B, length 6 inches, number of observations 162.

4. Distribution of the Coating On the Galvanized Specimens

The distribution of the coating on the galvanized specimens was measured by a magnetic method.[3] The measurements were made on one 14-inch (35 cm) length of galvanized pipe selected at random from the lot of specimens before burial, and on a 6-inch (15 cm) section cut from a second specimen from the same lot. A total of 389 measurements of thickness were made on the 14-in. length of pipe (identified as specimen A), and 162 measurements were made on the 6-in. section (identified as specimen B).

The measurements of coating thickness are shown as frequency distribution curves in Figure 2. These curves indicate not only that the specimens differed widely in coating thickness, but that the distribution of the coating on the individual specimens was highly variable as well. The variation did not fall in any particular pattern.

5. Thickness of the Outer Zinc Coating And of the Alloy Layer

The thickness of the outer zinc coating and of the alloy layer was measured by modifications of the electrolytic stripping methods described by Britton[4] and by Anderson and Manuel.[5]

The electrolytic cell consisted of a 4-ounce (120-ml) plastic bottle from which the bottom had been removed. The cathode was a strip of zinc 1.5 inches (38 mm) in width formed so as to fit tightly around the inner periphery of the bottle. Contact with the coating was made by means of a hole 0.19 in. (5 mm) in diameter in a No. 8 rubber stopper. A larger hole bored partly through one end of the stopper permitted the stopper to be placed over the mouth of the bottle. The electrolyte was a solution containing 20 g of NaCl, 10 g of $ZnSO_4$, and 100 g of H_2O.

In operation, the bottle was inverted and the test piece placed in contact with the hole in the stopper with sufficient pressure to prevent leakage of the electrolyte. By means of a 6-volt storage battery shunted by a variable voltage divider, an initial

TABLE I—Properties of the Soils at the Test Sites

TEST SITES				Moisture Equivalent	Apparent Specific Gravity	Resistivity at 60° F (15.6° C)	pH	Total Acidity[a] (Milligram Equivalent per 100 g of soil)	Composition of Water Extract (Milligram Equivalent per 100 g of soil)						
Environment and Soil Type	Soil No.	Location	Aeration						Na+K as Na	Ca	Mg	CO_3	HCO_3	Cl	SO_4
Inorganic Oxidizing-Acid Soils															
				Percent		Ohm-cm									
Cecil clay loam	53	Atlanta, Ga.	Good	33.7	1.60	17,800	4.8	5.1	....	....	....	....	....	....	....
Hagerstown loam	55	Loch Raven, Md.	do	32.0	1.49	5,210	5.8	10.9	....	....	....	....	....	....	....
Susquehanna clay	62	Meridian, Miss.	Fair	34.6	1.79	6,920	4.5	12.0	....	....	....	....	....	....	....
Inorganic Oxidizing-Alkaline Soils															
Chino silt loam	65	Wilmington, Calif.	Good	26.4	1.41	148	8.0	A	7.65	12.40	2.20	0.00	1.30	6.05	16.90
Mohave fine gravelly loam	66	Phoenix, Ariz.	Fair	16.5	1.79	232	8.0	A	6.55	0.51	0.18	.00	0.73	2.77	2.97
Inorganic Reducing-Acid Soils															
Acadia clay	51	Spindletop, Tex.	Poor	47.1	2.07	190	6.2	13.2	10.27	15.55	5.03	0.00	0.56	5.75	22.00
Sharkey clay	61	New Orclans, La.	do	30.8	1.78	943	6.8	4.9	0.73	0.68	0.33	.00	.71	0.10	0.91
Inorganic Reducing-Alkaline Soils															
Docas clay	64	Cholame, Calif.	Fair	41.1	1.88	62	7.5	A	28.10	2.29	0.76	0.00	0.89	28.80	0.26
Lake Charles clay	56	El Vista, Tex.	Very poor	28.7	2.03	406	7.1	5.1	3.12	0.69	.47	.00	.80	1.59	3.04
Merced silt loam	70	Buttonwillow, Calif.	Fair	24.7	1.69	278	9.4	A	8.38	.38	.22	.02	1.87	1.12	5.57
Organic Reducing-Acid Soils															
Carlisle muck	59	Kalamazoo, Mich.	Very poor	43.6	....	1,660	5.6	12.6	1.03	3.08	2.70	0.00	0.00	3.47	1.04
Muck	58	New Orleans, La.	Poor	57.8	1.43	712	4.8	15.0	2.03	2.23	1.29	.00	.00	0.47	2.54
Rifle peat	60	Plymouth, Ohio	do	43.4	1.28	218	2.6	297.4	2.91	10.95	2.86	.00	.00	.00	56.70
Tidal marsh	63	Charleston, S.C.	Very poor	46.7	1.47	81	6.9	14.6	33.60	6.85	4.00	.00	.00	12.70	36.60
Cinders															
Cinders	67	Milwaukee, Wis.	Very poor	.....	.....	455	7.6	A	0.77	3.03	0.53	.00	.55	0.08	2.89

[a]A, Alkaline reaction.

current of 25 ma was passed through the cell with the test piece as the anode, the current being read on a recording milliammeter. As the outer zinc coating was removed by electrolysis and different phases of zinc-iron alloy and finally steel were exposed, the changes in potential associated with each phase produced corresponding changes in the recorded current.

The interpretation of the current-time curves in terms of coating thickness is illustrated by Figure 3. The minimum thickness of the zinc layer is measured by the horizontal part of the curve at point A. On exposure of an alloy layer locally, the counter emf increases, and the current proportionally decreases until the zinc is completely removed and a uniform layer of the first phase of the alloy layer is exposed (point B). The current then remains unchanged until a second phase of the alloy layer is exposed and so on through the various phases until the underlying steel is completely exposed. The minimum thickness of the alloy layer, including the intermediate phases, is represented by the distance *BC*, and the maximum thickness by the distance *AD*. The reported thicknesses were computed from the areas under the curve. For the present investigation the thickness of the zinc coating was taken as the maximum thickness, that is, to point *B*, and the thickness of the alloy layer was taken as being represented by the distance *BD*.

The maximum thickness of the outer zinc coating and of the alloy layer at several points on two specimens are recorded in Table II. These data indicate that a large part of the zinc applied to the steel pipe was converted to alloy layer.

6. Condition of Coating, Weight Loss, and Pitting of Galvanized Steel, Bare Steel, and Zinc

After each exposure period, one set of specimens was removed, returned to the laboratory, and cleaned free of corrosion products by previously described methods.[2] Photographs of the specimens of galvanized steel, bare steel, and zinc removed from the different sites after exposure for 13 years are shown in Figure 4.

The losses in weight and the depths of the deepest pits on the specimens, together with the percentage of the area of the galvanized specimens on which coating remained, are recorded in Table III for the different periods of exposure. Except as indicated, each value is the average of measurements made on two specimens.

The data of Table III reveal that in nearly one-half of the total number of soils (53, 55, 61, 62, 64, 65, 66, and 70) the coating remained virtually intact and consequently provided complete protection to the

TABLE II—Thickness of the Outer Zinc Coating of the Alloy Layer, and of the Total Coating on Galvanized Specimens
[In mils]

SPECIMEN	Zinc Layer	Alloy Layer	Total Coating
A	1.8	2.3	4.1
A	0.9	3.4	4.3
A	2.0	2.3	4.3
A	2.0	3.0	5.0
B	2.7	3.2	5.9
B	2.8	3.2	6.0

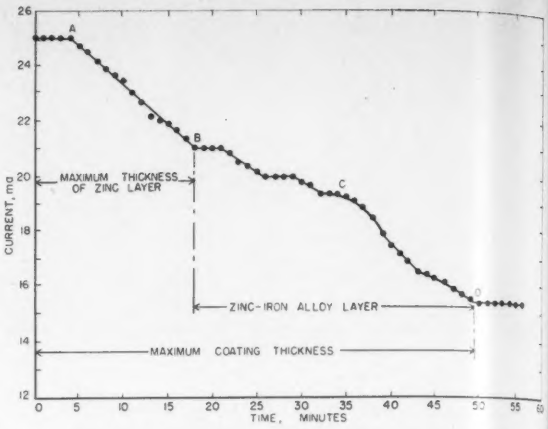


Figure 3—Thickness of the outer zinc coating and of the alloy layer.

underlying steel for the maximum period of exposure. However, in the highly reducing soils (51, 56, 58, and 60) and in cinders (67) little, if any, of the coating remained at the conclusion of the test.

In certain soils, such at 58 and 60, failure of the coating during the first few years of exposure resulted in a rate of corrosion of the galvanized specimens comparable to that of bare steel. But in other soils, contrary to expectations, destruction of the coating was not accompanied by rapid corrosion of the underlying steel. For example, the galvanized specimens in soils 51 and 56 corroded relatively slowly during the greater part of the exposure period in spite of the fact that the coating was almost completely removed by corrosion during the first few years of exposure. Even in the highly corrosive cinders, soil 67, the galvanized specimens corroded much more slowly than the specimens of bare steel.

The progress of corrosion of galvanized steel, bare steel, and zinc in the different soils is shown by the weight loss and pit depth-time curves of Figure 5. The values for weight loss and pitting of the galvanized specimens on which the coating remained intact naturally apply to the coating and not to the basis metal.

The weight loss and pit-depth—time curves for the galvanized specimens in soils 64, 65, 66, and 70 are of particular interest in indicating that zinc coatings were effective in protecting steel against corrosion in soils that are highly corrosive to steel. For example, in spite of the fact that the steel specimens in soil 66 were perforated by corrosion after exposure for a few years, the coating on the galvanized specimens in this soil remained perfectly continuous throughout the entire period of the test. In soil 70, the specimens of both zinc and steel were severely corroded, but the coating on the galvanized specimens provided complete protection to the underlying steel.

The weight loss and pit depth-time curves for the galvanized specimens (Figure 5) show that the zinc coatings provided good protection in all of the 10 inorganic soils with the exception of the highly reducing soil 56. However, in only one of the four organic soils (59) could protection be considered

TABLE III—Loss in Weight and Maximum Penetration of Galvanized [a] and Bare Steel Pipe and Zinc Plate

[Average of two specimens]

Soil No.	SOIL TYPE	Exposure	GALVANIZED STEEL						BARE STEEL		ZINC	
			Condition of Surface				Loss in Weight	Maximum Penetration	Loss in Weight	Maximum Penetration	Loss in Weight	Maximum Penetration
			Coated With Zinc and Alloy Layer	Coated With Zinc	Coated With Alloy Layer	Bare Steel Exposed						
	Inorganic Oxidizing-Acid Soils											
		Years	Percent	Percent	Percent	Percent	oz/ft²	Mils	oz/ft²	Mils	oz/ft²	Mils
		2.1	85 to 100	60 to 100	0 to 40	0	0.3	9	1.8	42	0.2	10
		4.0	100	20 to 40	60 to 80	0	1.4	6	2.9	98	.6	10
53	Cecil clay loam	8.9	100	20 to 40	60 to 80	0	0.6	<6	3.4	74	1.1	13
		11.2	100	30	70	0	1.0	<6	3.4	78	1.6	16
		12.7	100	20	80	0	0.6	<6	3.9	68	2.2	17
		1.9	100	60 to 100	0 to 40	0	.3	<6	1.8	33	0.4	13
		3.9	100	20 to 40	60 to 80	0	1.2	8	2.6	50	.6	8
55	Hagerstown loam	9.0	95	20 to 40	55 to 75	<5	0.7	6	4.1	92	.7	8
		11.0	100	70	30	0	1.0	<6	3.9	84	1.3	10
		12.6	100	70	30	0	0.6	<6	3.4	73	1.2	9
		2.1	100	50 to 100	0 to 50	0	1.0	12	3.2	40	0.6	9
		4.0	100	20 to 40	60 to 80	0	2.3	9	4.3	56	1.2	9
62	Susquehanna clay	8.9	100	0 to 20	80 to 100	0	0.9	<6	5.3	68	1.3	12
		11.2	100	80	20	0	1.1	<6	6.0	72	1.3	11
		12.7	100	75	25	0	0.8	<6	6.8	79	1.7	9
	Inorganic Oxidizing-Alkaline Soils											
		2.1	100	20 to 40	60 to 80	0	1.1	<6	4.3	50	0.5	30
		4.0	100	0 to 20	80 to 100	0	2.3	6	4.6	59	.8	36
65	Chino silt loam	9.0	95	50 to 75	25 to 50	<5	1.6	<6	7.0	65	1.4	56
		11.2	95	0	95	<5	1.7	<6	6.2	84	1.1	40
		12.7	100	0	100	0	1.1	<6	7.2	98	1.8	56
		2.1	100	60 to 100	0 to 40	0	1.6	6	9.2	[d]145+	1.7	25
		4.0	100	20 to 40	60 to 80	0	3.3	8	12.3	145+	[b]2.6	28
66	Mohave fine gravelly loam	9.0	95	20 to 40	60 to 80	5	1.1	<6	8.1	78	0.9	44
		11.2	95	0	95	5	2.7	<6	16.3	145+	4.4	56
		12.7	100	0	100	0	1.1	<6	[b]20.3	145+	5.5	34
	Inorganic Reducing-Acid Soils											
		2.1	100	60 to 100	0 to 40	0	0.6	6	2.2	40	0.5	12
		4.0	100	20 to 40	60 to 80	0	1.5	12	5.0	45	1.0	8
61	Sharkey clay	8.9	95	75 to 95	5 to 20	<5	0.7	<6	4.2	48	1.1	14
		11.2	95	0	95	<5	2.2	6	6.9	58	2.1	17
		12.7	100	0	100	0	1.1	6	7.5	64	2.0	14
		2.1	15	0	15	85	3.3	6	7.5	52	2.0	30
51	Acadia clay	[c]9.0	<5	0	<5	95	4.8	8	17.4	128+	4.8	28
	Inorganic Reducing-Alkaline Soils											
		2.1	100	0 to 20	80 to 100	0	3.2	8	8.7	80	0.7	16
		4.0	100	20 to 50	50 to 100	0	1.6	9	6.0	67	.6	18
64	Docas clay	9.0	95	75 to 95	5 to 20	<5	1.6	10	4.7	80	1.4	79
		11.2	95	0	95	5	2.4	<6	12.4	118	1.6	35
		12.8	95	0	95	<5	1.6	<6	[b]17.2	122	2.0	[b]21
		2.1	100	60 to 100	0 to 40	0	2.1	8	4.9	50	1.7	56
		4.0	100	0 to 20	80 to 100	0	4.5	12	[b]9.7	118+	[c]1.6	102+
70	Merced silt loam	9.0	100	20 to 40	60 to 80	0	0.1	6	13.4	122	3.6	84
		11.2	85	0	85	15	2.6	8	24.5	145+	D	150+
		12.8	90	0	90	10	1.3	8	21.3	145+	D	150+
		2.1	5 to 15	0	5 to 15	85 to 95	3.7	5	13.8	77	1.1	10
		4.0	5 to 15	0	5 to 15	85 to 95	3.9	7	16.0	104	3.4	26
56	Lake Charles clay	8.9	<5	0	<5	95	5.5	13	27.8	145+	4.5	29
		11.1	<5	0	<5	95	14.3	26	[f]D	145+	6.6	42
		12.7	<5	0	<5	95	13.8	66	D	145+	[b]9.0	[b]53
	Organic Reducing-Acid Soils											
		2.1	30 to 50	0	0	50 to 70	1.2	8	1.5	12	0.7	66
		4.0	30 to 50	0	0	50 to 70	3.4	11	3.3	20	1.7	10
59	Carlisle muck	9.1	50	0	20 to 50	50	3.0	8	7.5	101	4.6	22
		11.1	50	0	50	50	4.0	8	9.6	76	3.9	28
		12.7	40	0	40	60	3.4	<6	9.6	72	4.6	18
		2.1	100	50 to 100	0 to 50	0	1.2	<6	2.7	24	1.2	26
		4.0	100	50 to 100	0 to 50	0	2.1	10	9.2	38	[b]2.3	34
63	Tidal marsh	8.9	95	0	95	5	2.0	8	10.7	80	[g]2.0	25
		11.2	75	0	75	25	2.9	8	12.2	94	3.8	30
		12.6	60	0	60	40	[b]4.8	[b]52	1.85	126	4.1	43
		2.1	5 to 15	0	5 to 15	85 to 95	4.3	13	5.1	29	3.3	38
		4.0	0	0	0	100	5.4	[b]21	8.8	46	5.1	66
58	Muck	9.1	0	0	0	100	9.0	64	17.3	98	7.4	58
		11.1	0	0	0	100	8.3	66	16.3	110	7.6	75
		12.7	0	0	0	100	10.7	76	17.6	124	7.5	50
		2.1	0	0	0	100	4.3	10	4.0	15	4.6	53
		4.0	0	0	0	100	7.2	12	8.1	[b]38	10.4	100
60	Rifle peat	9.1	0	0	0	100	19.8	83+	17.6	58	D	150+
		11.1	0	0	0	100	17.9	66	19.6	89	D	150+
		12.7	0	0	0	100	19.5	88	21.0	118	D	150+
	Cinders											
		2.1	0	0	0	100	6.7	62	40.5	145+	[e]4.6	107+
		4.0	0	0	0	100	5.4	45	[e]37.0	145+	[e]12.2	118+
67	Cinders	9.0	<5	0	<5	95	5.6	21	31.7	145+	D	150+
		11.1	0	0	0	100	17.2	62	D	145+	12.0	78
		12.7	<5	0	<5	95	[b]11.9	[b]48	D	145+	D	150+

[a]Nominal weight of coating, 3.08 oz/ft².
[b]Data for the individual specimens differed from the average by more than 50 percent.
[c]Data for 8 specimens.
[d]The plus sign indicates that 1 or more specimens contained holes because of corrosion.
[e]Data for 1 specimen. The other specimens were destroyed by corrosion.
[f]D, both specimens destroyed by corrosion.
[g]Data for 1 specimen. The other specimen was missing.

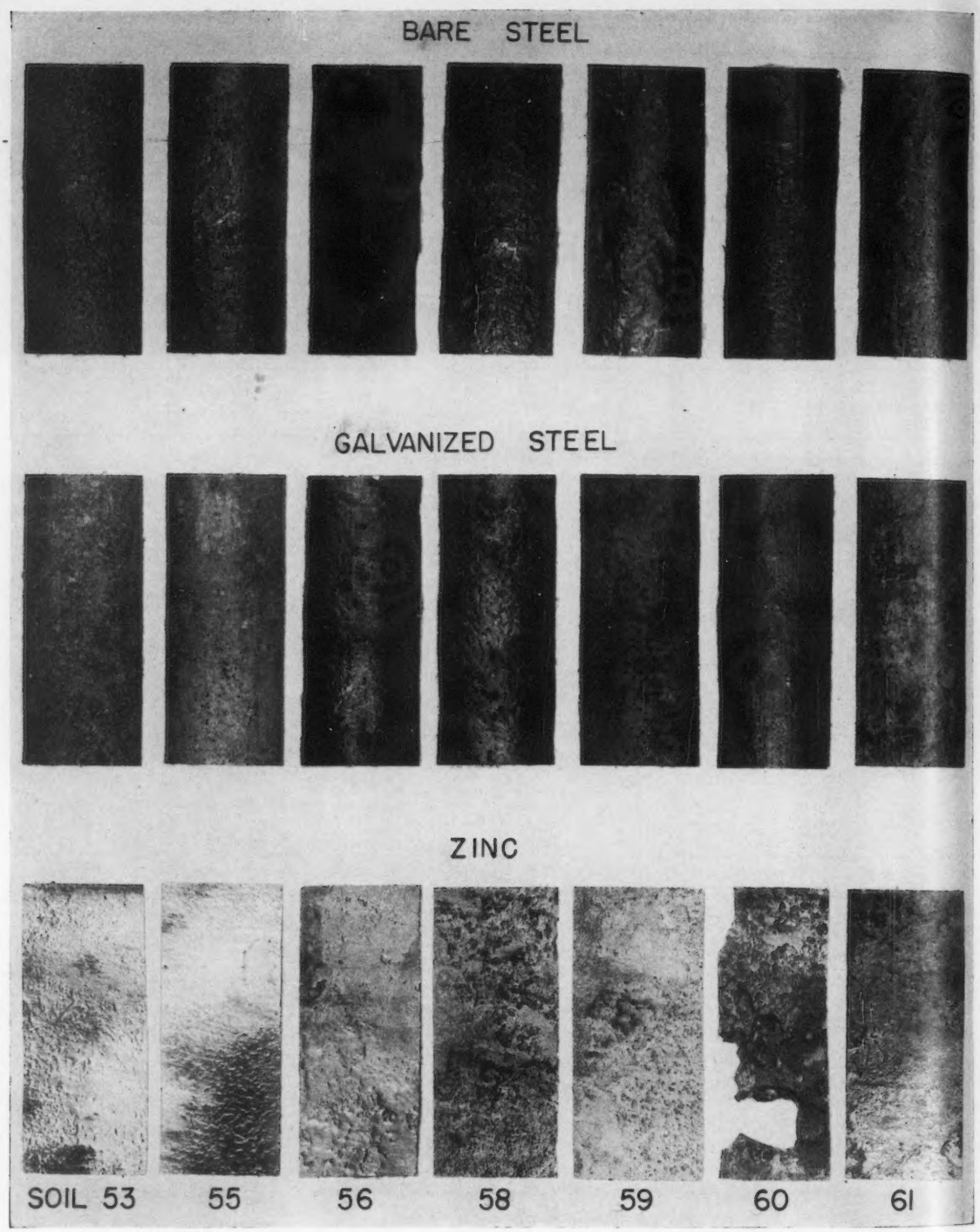


Figure 4—Condition of specimens of bare steel, galvanized steel and zinc after exposure for 13 years to 14 soils.

adequate. In two of these soils, 58 and 60, the effectiveness of the zinc coating was negligible. Although it is not surprising that severe corrosion of galvanized steel occurred in these organic soils because of their corrosiveness toward zinc, it is evident from the curves in Figure 5 that a high rate of corrosion of zinc in a soil does not indicate necessarily that galvanized steel would also be subject to corrosion.

The data presented on the condition of the coating on the specimens (Table III) indicate that the specimens removed from sites 64, 65, 66, and 70 after exposures for 11 and for 13 years contained no zinc whatever. Because these specimens were covered

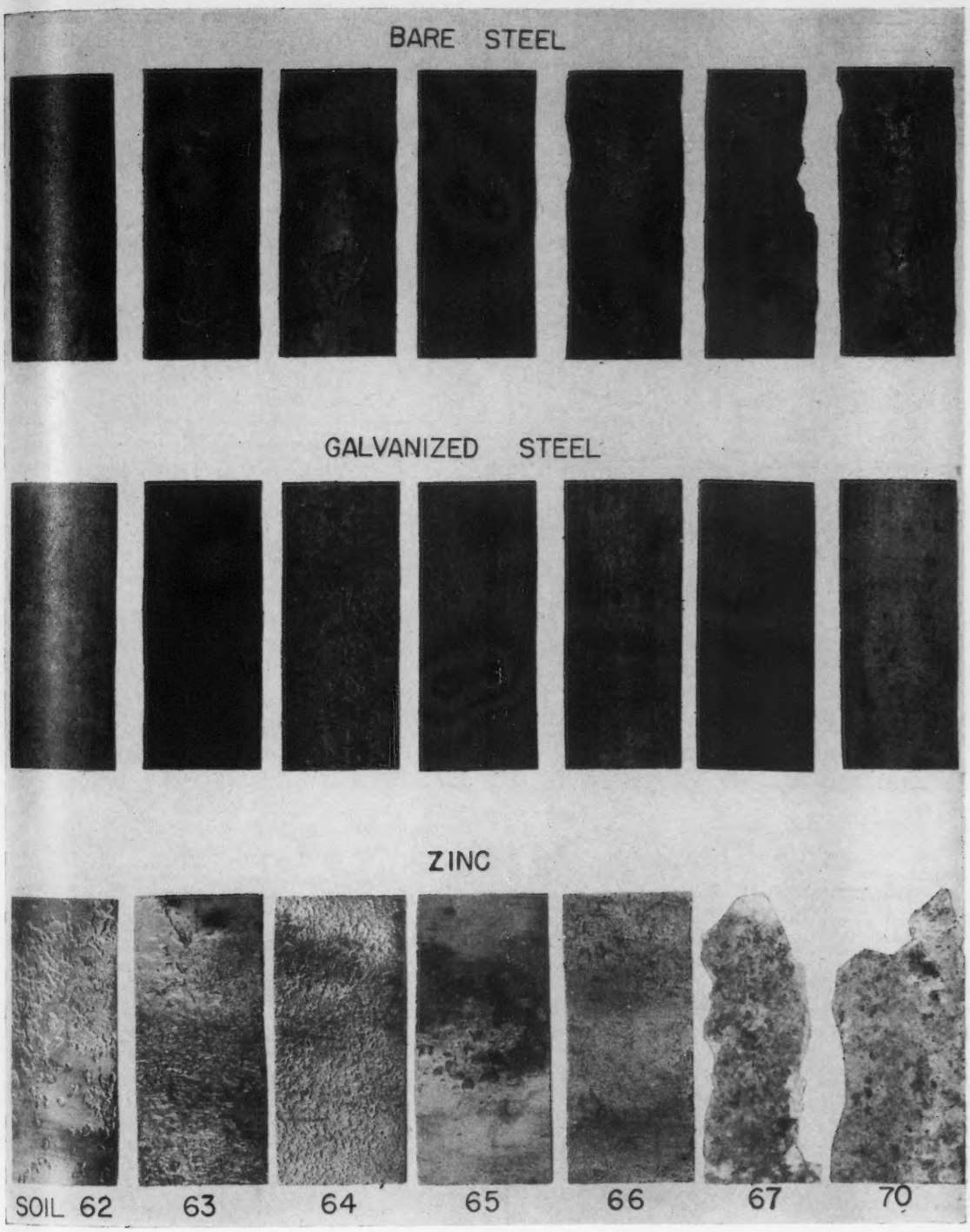


Figure 4—Continued.

with zinc-iron alloy layer, it might be assumed that the alloy layer protected the steel pipe electrochemically or otherwise, but unpublished results of measurements of the potentials and of the polarizing characteristics of these materials, supplemented by measurements of weight loss, indicate that the zinc-iron alloy layer cannot protect steel cathodically in soils, nor is it more resistant to corrosion than steel.

Additional evidence that galvanic action between zinc and steel does not fully account for the behavior of the galvanized specimens is provided by the data on weight loss and pitting of the specimens removed from sites 51 and 67 (Table III). Although both the outer zinc coating and the alloy layer were completely

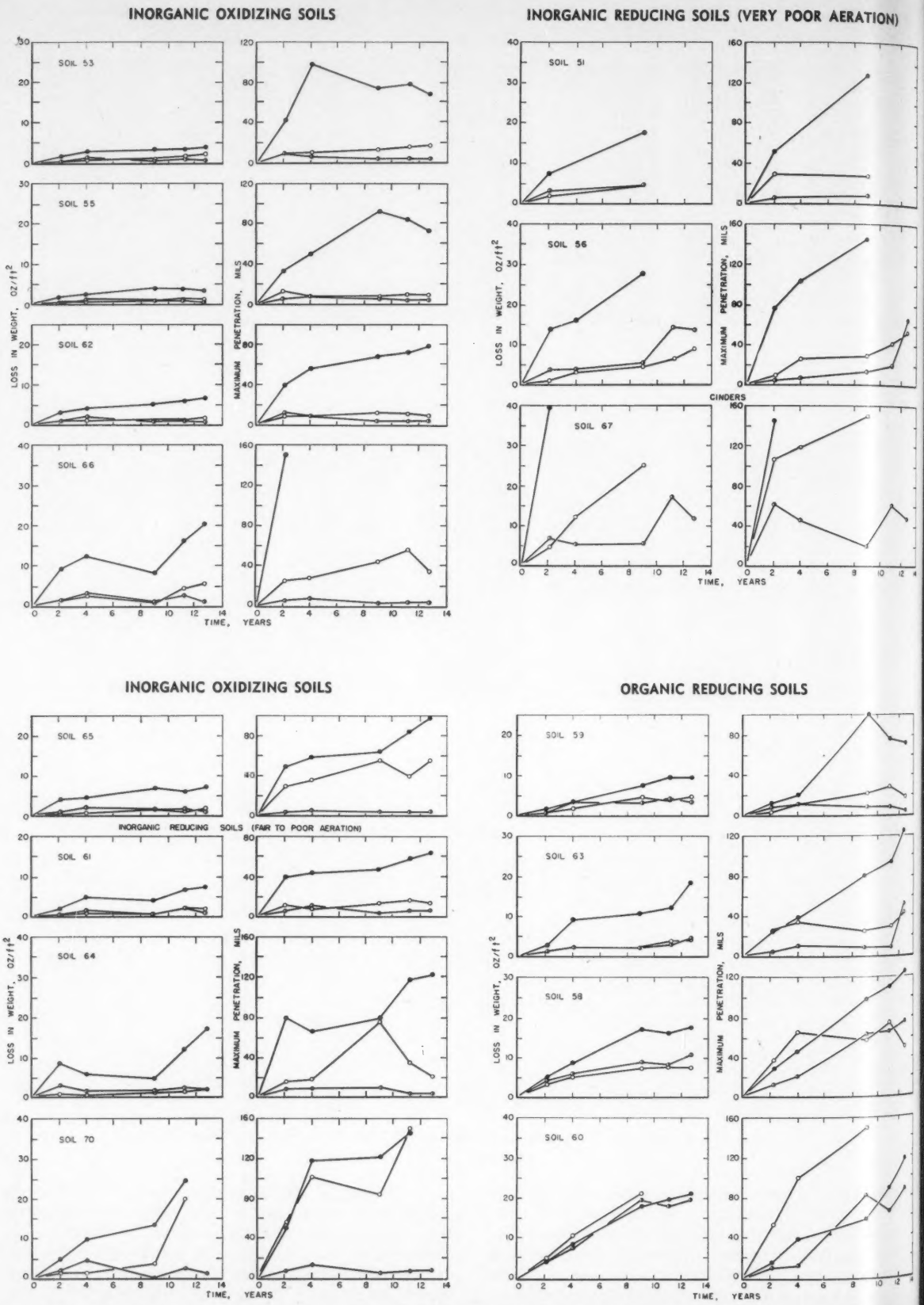


Figure 5—Weight-loss and maximum penetration—time curves of galvanized steel, bare steel and zinc. ● Bare steel. ○ Zinc. ◑ Galvanized Steel.

removed from the specimens during the initial period of exposure, the weight losses and pitting of the galvanized specimens during the remaining periods of exposure were considerably less than they were on the bare steel specimens. There are some indications that the relatively high resistance to corrosion of the galvanized specimens is due to an inorganic film or coating deposited by galvanic action between the outer zinc coating and the alloy layer or steel. The composition and properties of this film, which is presumably silicious in nature, are currently under study.

Reference has previously been made to an earlier series of field tests in which were included galvanized specimens having the same nominal weight of coating as those in the present test, namely, 3 oz/ft².[1,2] In comparing the behavior of these two sets of specimens, Blum and Brenner[6] concluded that the specimens in the later test corroded as a group as much in 4 years as did the specimens in the earlier tests in 10 years. A further examination of these data, however, indicates that this observation is not entirely correct. The data for the 1924 specimens removed after 10 years are reported as an average rate of loss of weight in ounces per square foot (or penetration) per year, whereas those for the 1937 specimens are reported as total loss of weight (or total penetration) after 4-year exposure. Comparison of the two sets of specimens on this basis is difficult because most corrosion occurs during the first few years of exposure and the rate decreases considerably after this initial rapid corrosion.

A better comparison may be made of the two sets of specimens after each had been exposed for 10 years. Seven of the soil sites either were common to the two series of tests or were located in soils of the same type, differing only in geographical location, making possible a comparison of the two sets under the same soil conditions. The weight losses and the maximum penetration of these specimens, both bare and galvanized, exposed to the same soil conditions are given in Table IV. Because the specimens buried in 1937 were not removed after exposure for 10 years as were the earlier specimens, it was necessary to interpolate the weight loss and pit depth-time curves for these specimens (Figure 5) between the points for 9 and 13 years. In 5 of the soils, 3 (53), 11 (55), 40 (61), 42 (62), and 43 (63) there is no significant difference in corrosion. In two soils, 23 (70) and 29

TABLE IV

Comparison Between Different Lots of 3-oz. Galvanized Samples Exposed to the Same Soil Conditions for 2 Different 10-yr. Periods.

SITE NUMBER		GALVANIZED STEEL				BARE STEEL, WEIGHT LOSS	
		Weight Loss		Maximum Penetration			
1924	1937	1924	1937	1924	1937	1924	1937
		oz/ft²	oz/ft²	Mils	Mils	oz/ft²	oz/ft²
3	53	0.4	0.8	<6	<6	4.0	4.0
11	55	.9	1.0	<6	9	1.8	4.0
23	70	9.6	1.5	68	7	25.7	18.5
29	58	6.0	8.5	<6	63	14.8	16.8
40	61	0.9	1.5	<6	<6	7.5	5.5
42	62	0.7	1.0	<6	<6	10.6	5.5
[a]43	63	1.4	2.5	<6	8	12.7	11.5

[a]Site 43 is not identical with site 63 geographically, but the soil environment, tidal marsh, is the same.

TABLE V—Condition or Maximum Penetration of Galvanized Pipe and 16-Gage Steel Sheet

[Maximum penetrations, in mils]

Z, Zinc continuous over specimen; A, zinc-iron alloy layer exposed over at least a part of the specimen; R, rusted; M, shallow metal attack.

SOIL NUMBER	COATING WEIGHT (oz/ft²) ON—					
	Sheet[a]			Pipe		
	0.81	0.99	1.07	1.81	2.82	3.08
Inorganic Oxidizing—Acid Soils						
3	R	R	Z	M	Z	.....
53	.....	.....	.....	.....	.....	A
4	16	22	13	R	R	.....
6	A	A	Z	.....	Z	.....
10	24	16	12	A	R	.....
11	21	16	13	.....	A	.....
55	.....	.....	.....	.....	.....	A
12	M	A	A	A	.....	.....
16	15	20	18	Z	M	.....
19	20	27	22	A	Z	.....
22	32	56	29	.....	R	.....
24	A	A	Z	Z	Z	.....
25	R	10	R	.....	Z	.....
26	6	11	8	A	A	.....
31	A	Z	Z	.....	Z	.....
32	R	A	A	R	R	.....
35	R	A	A	A	A	.....
36	4	A	A	.....	Z	.....
38	A	A	A	.....	Z	.....
41	A	A	A	M	A	.....
42	.....	21	23	.....	R	.....
62	.....	.....	.....	.....	.....	A
46	Z	Z	Z	A	Z	.....
Inorganic Oxidizing—Alkaline Soils						
13	R	15	8	.....	R	.....
65	.....	.....	.....	.....	.....	A
66	.....	.....	.....	.....	.....	A
Inorganic Reducing—Acid Soils						
1	30	30	33	29	R	.....
2	R	A	Z	M	Z	.....
5	22	12	12	.....	R	.....
7	17	17	22	R	R	.....
9	19	29	23	R	A	.....
14	A	A	R	A	Z	.....
17	27	22	19	R	R	.....
27	10	12	9	.....	A	.....
28	63	33	22	.....	R	.....
30	13	20	11	12	A	.....
37	17	20	14	.....	R	.....
40	48	47	38	R	R	.....
61	.....	.....	.....	.....	.....	M
44	A	A	A	.....	.....	.....
51	.....	.....	.....	.....	.....	15
Inorganic Reducing—Alkaline Soils						
8	R	A	A	R	Z	.....
15	A	Z	Z	.....	Z	.....
20	21	17	13	R	R	.....
23	21	37	41	.....	68	.....
70	.....	.....	.....	.....	.....	7
45	5	19	16	38	R	.....
47	R	R	R	A	A	.....
56	.....	.....	.....	.....	.....	17
64	.....	.....	.....	.....	.....	7
Organic Reducing—Acid Soils						
29	26	32	28	30	R	.....
58	.....	.....	.....	.....	.....	65
33	29	17	14	.....	R	.....
43	63	R	R	25	A	.....
63	.....	.....	.....	.....	.....	8
59	.....	.....	.....	.....	.....	8
60	.....	.....	.....	.....	.....	75
Cinders						
67	.....	.....	.....	.....	.....	40

[a] Weights of the coating on one side. This is half the nominal weight of the coating on sheets.

(58) real differences, particularly in penetration, are found. In the case of soil 23 (70) the penetration was greater in the 1924 specimens, but in the other, 29 (58), the penetration was greater in the 1937 specimens.

As pointed out previously there is a wide range in coating thickness of the specimens buried in 1937 (Figure 2) and a similar but somewhat smaller range in the 1924 specimens. The excellent agreement in results of the tests of the two sets of specimens in five soils indicate that these thickness differences were of little significance and that the difference in corrosion of the specimens in the other two soils must have been due to local environmental changes, such as drainage, aeration, etc., over the two periods of time.

7. Effect of Weight of Coating

Logan and Ewing[1] studied the effect of weight of coating on the loss in weight of galvanized specimens exposed to corrosion in six soils, representing a wide range of conditions, for periods of 6, 8, and 10 years. Their results showed that the weight loss decreased with increase in weight of coating to a certain limiting value beyond which it was constant. On the basis of this relation and other considerations, the conclusion was drawn that galvanized coatings for underground use should have a weight of not less than 2 oz/ft² of exposed surface. Although Logan and Ewing showed a rough correlation between weight loss and pitting, no attempt was made to relate the rate of pitting of the specimens directly to coating weight.

In order to obtain a direct relation between the pitting of galvanized steel specimens and weight of coating, the depths of the deepest pits after 10 years exposure on the specimens studied by Logan and Ewing were averaged for the same six soils and plotted against the corresponding weights of coating. In obtaining the values shown in Figure 6, the pit depths on specimens having coating weights within the ranges 0.8 to 0.9, 0.9 to 1.0, etc. oz/ft² were averaged. These average values also include data for specimens of different basis metals, namely, open-hearth iron, wrought iron and copper bearing steel, no specific effect of the basis metal on weight loss having been observed. Each point shown in Figure 6 is the average of measurements made on from 12 to 36 specimens, usually the latter. The values for the standard deviation of the pit depths for the different coating thicknesses are seen to decrease markedly with increase in coating thickness. For the soil conditions represented, a zinc coating having a nominal weight of 2 oz/ft² of exposed surface would prevent appreciable pitting of steel for at least 10 years, assuming reasonably uniform distribution of the coating.

As the pit depth data shown in Figure 6 apply to specimens of galvanized steel which were exposed to a variety of soil environments, an optimum weight of coating that might be selected on the basis of these data might be excessive in some specific environment but insufficient in others. In Table V are shown the depths of the deepest pits on the specimens exposed in the earlier series of tests,[1] from which can be

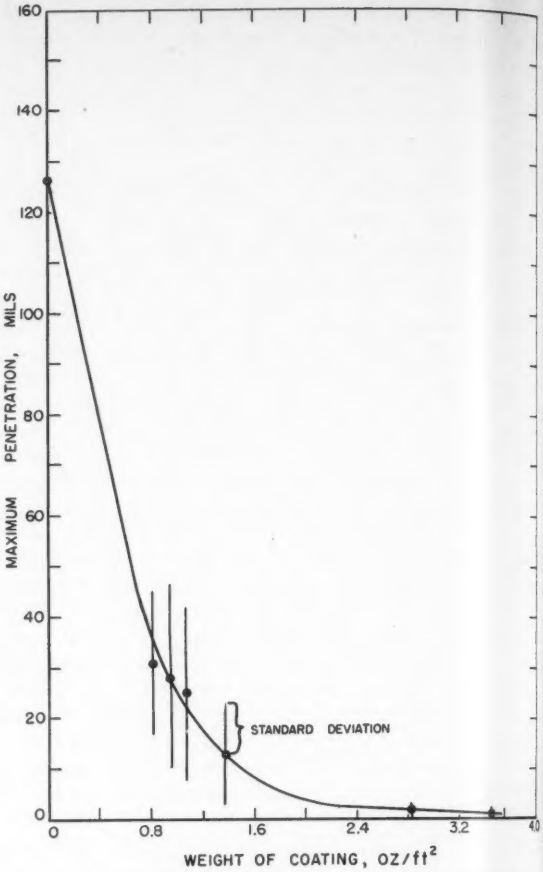


Figure 6—Correlation between maximum penetration and weight of coating on galvanized pipe and sheet exposed 10 years in 6 soils (Data of Logan and Ewing).

determined the minimum weight of coating required to protect steel for 10 years in specific soil environments. Data for the specimens buried in 1937 are also included in the table.

It will be observed that in the group of oxidizing, inorganic soils, pitting occurred on the specimens having a weight of coating of 1.07 oz/ft² or less, but no pits developed on the specimens having a coating of 1.81 oz/ft.² Hence it is reasonable to conclude that a nominal 2-oz. coating is probably adequate for oxidizing soils for at least 10 years. A 3-ounce coating would provide adequate protection in the group of reducing inorganic soils except for highly reducing soils high in soluble salts, for example, 51 and 56. These latter soils and the group of reducing organic soils and cinders would require a coating in excess of 3 oz/ft.²

8. Summary

This report contains the results of measurements of corrosion made on specimens of galvanized steel, bare steel and zinc exposed to different soil conditions for periods up to 13 years. The nominal weight of the zinc coating was 3 oz/ft², but the actual thickness varied over a wide range. In approximately one-half of the 15 soils to which the specimens were exposed, the coating on the galvanized specimens remained

virtually intact throughout the entire duration of the field test. The galvanized specimens were especially resistant to corrosion in alkaline soils that were highly corrosive to bare steel. In only two soils, both organic, failure of the zinc coating after relatively short exposures was accompanied by marked corrosion of the steel. The high corrosion resistance shown by most of the galvanized specimens after the outer zinc coating had been virtually removed by corrosion is tentatively attributed to a film or coating, probably silicious in nature, that was deposited cathodically by the galvanic action between the outer zinc coating and the alloy layer or the underlying steel.

The results of these tests show that the minimum weight of zinc coating required to protect steel from corrosion for a minimum of 10 years depends on the nature of the soil environment. In these exposure tests, a 2-ounce coating was sufficient to protect steel in inorganic oxidizing soils, but for inorganic moderately reducing soils a 3-ounce coating was required. Highly reducing, morganic and organic soils require coatings in excess of 3 oz/ft.[2]

The field tests described were initiated and installed, and until 1946 were conducted under the supervision of K. H. Logan.

9. References

1. Kirk H. Logan and Scott P. Ewing. *J. Research NBS*, **18**, 361 (1937) RP 982.
2. Kirk H. Logan. NBS Circular C450 (1945).
3. A. Brenner. *J. Research NBS*, **20**, 357 (1938) RP1081.
4. S. C. Britton. *J. Inst. Metals*, **58**, 211 (1936).
5. Stanley Anderson and R. W. Manuel. *Trans. Electrochem. Soc.*, **78**, 373 (1940).
6. William Blum and Abner Brenner. Corrosion Handbook, p. 814. John Wiley & Sons, Inc., New York 1, N. Y. (1948).

Corrosion of Low-Alloy Irons and Steels in Soils*

By IRVING A. DENISON and MELVIN ROMANOFF**

Abstract

The results of measurements of the corrosion of 10 low-alloy irons and steels exposed to 14 soils for periods up to 13 years are given. The magnitude and progress of corrosion as determined by weight-loss and pit-depth measurements are correlated with the composition of the materials and the nature of the environmental conditions to which the test specimens were exposed.

1. Introduction

IN 1932 the National Bureau of Standards in cooperation with a number of manufacturers and consumers of pipe materials initiated an extensive investigation of the corrosion of certain materials used in underground construction. Examination of the test specimens removed during the early periods of exposure indicated that certain alloy steels had improved corrosion resistance over ordinary irons and steels. Consequently, specimens representing a greater variety of alloy irons and steels were installed at the sites at intervals during the course of the exposure tests. The condition of the specimens removed from the various sites after successively longer periods of exposure has been described in a series of progress reports, and in 1950 a final report on the specimens buried in 1932 was published.[1] The present report contains the results of measurements of weight loss and pitting on samples of 10 varieties of irons and steels that were exposed in 1937 and removed from the test sites after five periods of exposure, ranging from 2- to 13-yr duration. The properties of the soils at the test sites, the installation of the specimens at the sites, and the methods used in cleaning the specimens removed prior to 1946 are described in earlier papers.[1, 2] Specimens subsequently removed were cleaned by immersion in fused sodium hydride.[3]

2. Description of the Materials

The specimens were in the form of plates 12 inches long and 25 inches wide, ranging in thickness from 0.175 to 0.265-inch. The compositions of the materials are given in Table I.

3. Results of the Exposure Tests

The corrosion of the different materials in typical soils is illustrated in Figures 1 and 2. Each of the four environmental groups based on aeration is represented as follows: good aeration, soil 55; fair aeration, soil 66; poor aeration, soil 61; and very poor aeration, soil 56.

The extent of corrosion damage was determined from the loss in weight of the specimens as a result of the exposure, and from the depths of the deepest pits. The results of these measurements for the different periods of exposure are given in Tables II and III. Unless indicated otherwise, these values are the averages of measurements on two specimens. The exposure periods did not differ from the average values given in the tables by more than 5 percent.

A number of the specimens exposed for the longer periods in the more corrosive soils were perforated by pitting. Because the depths of the pits producing these perforations would obviously have been greater after successively longer periods of exposure if thicker specimens had been used, some adjustment of the values for pitting of the perforated specimens was desirable. An approximate adjustment was made by multiplying the average penetration of the perforated specimens by the pitting factor, defined as the ratio of the maximum to the average penetration. Denison and Hobbs[4] showed that the pitting factor

★Reprinted from *J. Res Nat. Bur. Standards*, **49**, No. 5, 315-323 (1952) Nov. Research Paper No. 2367.
* National Bureau of Standards, Washington, D. C.

of plain irons and steels decreased with time during the early periods of exposure underground but became approximately constant after exposures for 6 to 8 years. The value of the pitting factor was considered by Denison and Hobbs to be characteristic of soils and Logan[2] showed that it varied directly with the aeration. Adjusted values of pit depths recorded in Table III are enclosed in parentheses.

The over-all behavior of materials and the effect of the various alloying constituents on the corrosion of iron and steel in the soils is indicated by the weight loss and pit depth-time curves shown in Figures 3 and 4. In preparing these curves, the values for weight loss and pit depth for each material in all of the soils, except 51,* were averaged for each period of exposure. The logarithms of these average values were then plotted against the logarithms of the periods of exposure.

The curves shown in Figure 3 and 4 conform to the equations

$$P = kT^n \quad (1$$
$$W = k'T^u \quad (2$$

where P is the depth of the deepest pit at the time T and W is the weight loss at the time T.

Converting to logarithms,

$$\log P = n \log T + \log k \quad (3$$
$$\log W = u \log T + \log k'. \quad (4$$

Hence $n(u)$ is the slope of the line and $k(k')$ is the intercept on the log $P(W)$ axis.

Equations (1 and (2 were derived originally by Logan, Ewing, and Denison,[5] and by Martin,[6] respectively.

The constants of the equations, expressing the initial corrosion rate of the materials and the change in the rate with time, were calculated by the method of least squares for each material in each soil. By means of these constants, values of the average weight loss and pitting of each material in all of the soils were calculated for the maximum periods of exposure. These values, together with the constants of the equations and their standard errors, are tabulated in Table IV.

In order to estimate the probability that the weight loss or pitting of each material was significantly different from the corresponding values for plain steel, taken as the reference material, the standard t-test was applied, and from the calculated values of t, the probability of the differences being due to chance was obtained.[7]

The weight loss and pitting data for the copper-molybdenum open-hearth irons O and N and for the nickel-copper steels J and B, presented in Figure 3 and in Table 4 show that these alloys corroded slightly less than the plain steel A. However, the probability is high that several of the observed differences are due to chance. Because mill scale was not removed from the specimens of steel B before burial, the data recorded for this steel cannot be taken as truly representing the effect of additions of 2 percent of nickel and 1 percent of copper on the corrosion of steel in these soils.

The average depths of the deepest pits on these materials, given by the values of the constant k (y-intercept), indicate that the low-alloy steels had a greater initial pitting rate than the plain steel. However, as the exposure increased, the rate of pitting of the alloy steels diminished more rapidly than the rate for the plain steel so that after 13 years the order of the materials was reversed.

The weight loss and pit depth data for the group of chromium and chromium-molybdenum steels, C, KK, D, E, and H, (Figure 4 and Table IV) exhibit similar but somewhat greater effects of the alloying constituents than the copper-molybdenum and copper-nickel irons and steels. Chromium reduced the weight losses in a fairly regular manner, but increased the initial pitting rates of the steels. However, the rates of pitting of the alloy steels decreased more rapidly with time than the rate for plain steel.

The separate effects of chromium and molybdenum on the pitting of steel are difficult to determine because the chromium steels also generally contain molybdenum. It will be observed that steels C and D, containing 1 and 5 percent of chromium, respectively, had pits of about the same depth. Within this range chromium alone in excess of 1 or 2 percent does not appreciably increase the resistance of the material to pitting. On the other hand, the influence of molybdenum in reducing pitting is quite definite because all of the chromium steels containing molybdenum, KK, E, and H, had shallower pits than the straight chromium steel D.

The pit-depth-time curves, Figures 3 and 4, indicate that the change in the rate of pitting with time depends on the composition of the steel. In general, the greater the amount of nickel, chromium and molybdenum in the steels, the greater was the change in the rate of pitting of the steels with time. It may be assumed that

* The data for the specimens in soil 51 were omitted because data were available for two periods only.

TABLE I—Composition of the Materials

MATERIAL	Identification	C	Si	Mn	S	P	Cr	Ni	Cu	Mo	Other Elements
		%	%	%	%	%	%	%	%	%	%
Open-hearth steel	A	0.033	0.002	0.029	0.017	0.006	0.049	0.034	0.052	....	
Copper-molybdenum open-hearth iron	O	.03	.003	.16	.032	.007	.02	.15	.45	0.07	
Copper-molybdenum open-hearth iron	N	.06	.001	.098	.029	.069	.02	.14	.54	.13	
Copper-nickel steel	[a]J	.06	.047	.49	.025	.095	....	.52	.95	....	
Nickel-copper steel	[b]B	.07	.14	.44	.022	.010	....	1.96	1.01	....	
Chrominum-silicon-copper-phosphorus steel	C	.075	.84	.20	.018	.124	1.02	0.022	0.428	....	
2% chromium steel with molybdenum	KK	.082	.51	.46	.015	.017	2.01	.07	.004	.57	
4 to 6% chromium steel	D	.077	.43	.37	.005	.015	5.02	.09	.008	....	
4 to 6% chromium steel with molybdenum	E	.074	.41	.32	.006	.013	4.67	.09	.091	.51	A10.030, Ti 0.02
4 to 6% chromium steel with molybdenum	H	.060	.39	.40	.014	.021	5.76	.17	.004	.43	A10.27.

[a] Some mill scale on the specimens at time of burial.
[b] Specimens completely covered with a hard, black mill scale at the time of burial.

[1] Figures in brackets indicate the literature references at the end of this paper.

TABLE II—Loss in Weight of Alloy Irons and Steels in Different Soils

[Average of two specimens, in ounces per square foot]

Identification	MATERIAL[a]	Average Exposure	AERATION, TEST SITE NUMBER AND SOIL TYPE[b]														
			GOOD AERATION				FAIR AERATION			POOR AERATION			VERY POOR AERATION				
			53 Cecil Clay Loam	55 Hagerstown Loam	62 Susquehanna Clay	65 Chino Silt Loam	64 Docas Clay	60 Mohave Fine Gravelly Loam	70 Merced Silt Loam	58 Muck	60 Rifle Peat	61 Sharkey Clay	51 Acadia Clay	56 Lake Charles Clay	59 Carlisle Muck	63 Tidal Marsh	67 Cinders
		Year															
A	Open-hearth steel	2.1	1.8	2.0	2.8	4.6	7.1	8.3	5.0	5.7	6.3	2.6	11.6	14.4	1.5	3.6	12.0
		4.0	3.2	2.6	3.7	5.3	7.4	16.8	10.6	9.9	9.5	5.4	.....	18.4	4.2	[c]6.2	34.3
		9.0	3.9	3.8	4.2	7.2	7.5	4.6	17.9	16.9	22.0	4.3	[d]19.1	28.0	9.9	[c]8.9	*D(36)
		11.1	3.4	3.3	5.0	6.1	[f]19.0	[f]17.7	24.0	17.2	15.8	7.3	.....	48.1	9.5	16.9	37.8
		12.7	4.0	4.0	5.9	8.2	18.6	19.9	25.7	18.1	21.7	8.1	.....	D(53)	11.1	16.5	D(42)
O	Open-hearth iron; 0.45 Cu, 0.07 Mo	2.1	2.1	2.0	3.0	5.0	8.0	9.1	5.4	5.8	4.1	3.0	7.5	12.4	1.3	2.5	33.8
		4.0	2.9	2.8	3.6	5.0	8.0	11.6	[f]11.0	9.9	7.4	5.6	.....	13.8	2.9	4.7	33.2
		9.0	3.4	4.7	4.6	6.4	6.4	5.9	13.6	17.3	16.4	4.8	[d]19.0	28.4	7.8	7.1	25.1
		11.1	3.7	3.7	5.0	5.3	13.3	16.4	22.9	17.0	21.1	7.9	.....	48.2	8.3	11.6	29.3
		12.7	3.7	3.3	5.2	8.9	18.5	15.2	21.8	17.5	17.9	8.6	.....	D(53)	10.1	15.9	30.5
N	Open-hearth iron; 0.54 Cu, 0.13 Mo	2.1	2.0	1.9	3.0	4.6	8.0	7.4	4.8	5.5	4.8	2.7	7.2	13.0	1.4	3.0	26.9
		4.0	3.0	2.7	3.7	5.0	6.6	12.0	[f]10.2	9.4	8.2	5.6	.....	17.4	2.9	4.7	27.7
		9.0	3.3	4.6	4.7	6.7	5.8	[f]6.9	15.0	17.0	14.5	4.6	[d]18.8	33.7	7.6	7.2	21.9
		11.1	3.5	3.5	5.2	5.5	14.7	[f]20.5	20.3	17.1	20.0	7.5	.....	45.2	7.9	9.1	27.5
		12.7	3.8	3.4	5.3	8.1	18.0	15.1	20.0	17.0	20.8	8.6	.....	D(50)	7.4	11.7	29.5
J	Copper-nickel steel; 0.95 Cu, 0.52 Ni	2.1	0.8	1.2	2.4	3.4	9.0	7.3	4.2	5.2	5.3	2.3	7.0	14.0	1.6	[c]2.5	20.3
		4.0	1.3	1.8	3.3	5.0	6.0	10.4	[f]7.6	10.6	8.6	4.8	.....	19.2	2.6	3.5	35.1
		9.0	2.4	3.5	4.0	6.2	4.7	8.2	17.3	16.0	18.8	3.9	[d]18.1	34.6	5.5	7.0	30.4
		11.1	2.8	2.6	5.4	4.7	17.7	17.8	22.7	17.6	20.1	6.7	.....	49.5	8.2	7.8	28.2
		12.7	3.0	2.6	5.5	8.8	23.2	25.5	20.0	18.7	14.3	7.9	.....	53.9	8.5	9.3	[c]17.4
B[e]	Nickel-copper steel; 1.96 Ni, 1.01 Cu	2.1	0.6	0.8	2.1	4.9	6.6	8.9	3.9	6.2	6.4	2.0	7.4	13.0	1.4	2.3	23.0
		4.0	1.1	1.2	2.9	5.0	4.9	11.4	7.8	11.0	9.6	3.9	.....	19.5	2.4	3.4	44.3
		9.0	2.8	2.6	2.9	7.6	7.1	3.1	18.4	17.7	24.1	3.2	[d]20.2	31.2	7.2	8.9	D(49)
		11.1	2.4	2.4	5.1	5.4	[f]21.2	[f]17.4	26.8	18.8	17.0	6.8	.....	45.9	7.8	7.3	31.9
		12.7	3.2	3.1	8.2	10.8	14.4	19.8	29.6	20.8	21.0	7.6	.....	D(50)	9.4	11.7	39.0
C	Cr-Si-Cu-P steel; 1.02 Cr, 0.42 Cu	2.1	1.5	1.3	1.9	4.4	4.9	6.9	5.4	4.4	5.8	2.4	9.2	12.5	1.1	2.4	17.7
		4.0	2.4	2.3	3.0	5.4	5.1	13.6	9.8	9.0	10.2	4.6	.....	20.8	2.5	4.1	13.9
		9.0	3.3	3.0	3.8	11.0	5.7	3.9	15.8	16.7	24.9	3.6	[d]19.6	28.1	7.8	[c]5.8	26.3
		11.1	2.9	2.7	4.7	9.9	10.6	[f]12.3	28.1	18.0	18.5	7.1	.....	44.0	7.5	7.9	25.2
		12.7	3.6	3.3	5.5	11.4	7.6	17.6	D(33)	18.7	18.0	7.1	.....	D(49)	8.5	7.8	D(31)
KK	2.01% chromium steel with 0.57 Mo	2.1	1.6	1.6	2.4	4.2	4.9	7.2	5.4	3.3	3.8	2.4	7.9	9.0	1.2	1.8	[f]18.1
		4.0	2.2	2.4	3.0	4.5	5.4	12.3	9.7	8.4	6.0	4.7	.....	14.5	2.5	3.1	16.4
		9.0	2.9	4.7	4.3	7.7	4.6	[f]6.0	13.5	12.9	13.8	4.1	[d]17.9	28.9	4.8	4.9	15.0
		11.1	3.0	2.8	3.8	7.3	8.5	[f]18.9	26.2	13.6	18.5	6.4	.....	34.3	7.9	5.3	20.4
		12.7	3.5	2.5	4.7	9.1	8.8	14.0	20.6	14.0	15.3	6.6	.....	34.2	7.3	6.7	13.7
D	5.02% chromium steel	2.1	0.9	0.7	0.7	2.3	4.5	5.8	4.9	4.1	4.5	0.6	6.6	9.4	0.4	1.8	17.1
		4.0	1.3	1.1	1.2	2.2	4.4	12.1	[f]10.0	5.9	6.6	1.6	.....	17.9	.9	3.8	18.1
		9.0	2.0	1.7	1.8	3.6	4.4	[f]3.5	19.1	7.5	14.8	1.1	[d]17.6	28.8	3.0	5.6	12.2
		11.1	2.1	1.7	2.2	2.8	10.0	[f]13.5	29.5	7.2	14.6	2.2	.....	43.1	4.8	6.0	7.9
		12.7	2.8	1.6	2.5	3.5	7.2	14.7	[c]22.8	7.8	17.2	1.9	.....	D(48)	3.1	9.2	10.3
E	4.67% chromium steel with 0.51 Mo	2.1	0.9	0.6	0.7	2.5	4.2	7.9	5.2	3.9	4.1	0.9	7.1	9.6	0.4	1.7	12.2
		4.0	1.6	1.2	1.1	2.1	5.2	12.0	9.9	7.2	6.2	1.8	.....	16.3	.8	5.2	[f]11.7
		9.0	2.0	1.7	2.0	3.3	4.2	[f]5.2	19.5	6.4	13.2	1.4	[d]16.2	28.2	2.5	5.3	11.2
		11.1	2.3	1.6	2.3	2.1	10.2	[f]13.9	26.0	8.1	14.9	2.4	.....	36.8	4.9	5.4	5.7
		12.7	2.9	1.7	2.4	3.8	6.4	14.6	[c]18.1	9.5	15.0	2.6	.....	D(41)	3.4	9.0	8.3
H	5.76% chromium steel with 0.43 Mo	2.1	[c]0.8	0.7	.07	2.5	5.9	8.4	5.0	3.5	4.6	0.8	[c]8.3	[c]11.4	0.2	[c]1.7	12.6
		4.0	1.4	1.1	1.3	2.2	5.0	14.5	10.2	[c]6.8	6.2	1.6	.....	14.3	.7	5.4	[f]12.9
		9.0	1.9	2.0	1.9	3.7	4.0	[f]5.0	17.6	6.1	14.2	[c]1.0	[d]16.7	.....	2.2	6.4	8.9
		11.1	2.0	1.8	2.4	2.1	9.0	12.2	29.1	....	19.0	1.9	.....	[c]44.8	4.4	6.4	7.8
		12.7	2.7	1.8	[c]2.1	3.6	8.5	15.2	[c]31.0	[c]7.1	14.4	1.8	.....	[c]D(49)	2.4	8.0	10.2

[a] See table 1 for composition of materials.
[b] See reference (1) for properties of soils.
[c] Data for 1 specimen.
[d] Average of 8 specimens.
[e] D. Both specimens destroyed by corrosion. The number in parentheses is the observed loss in weight.
[f] Data for the individual specimens differed from the average by more than 50 percent.

TABLE III—Maximum Penetration of Alloy Irons and Steels

[Average of two specimens, in mils]

Identification	MATERIAL[a]	Average Exposure	AERATION, TEST SITE NUMBER AND SOIL TYPE[b]														
			GOOD AERATION				FAIR AERATION			POOR AERATION			VERY POOR AERATION				
			53 Cecil Clay Loam	55 Hagerstown Loam	62 Susquehanna Clay	65 Chino Silt Loam	64 Docas Clay	60 Mohave Fine Gravelly Loam	70 Merced Silt Loam	58 Muck	60 Rifle Peat	61 Sharkey Clay	51 Acadia Clay	56 Lake Charles Clay	59 Carlisle Muck	63 Tidal Marsh	67 Cinders
		Year															
A	Open-hearth steel	2.1	40	42	34	47	44	86	56	31	30	34	54	80	6	18	46
		4.0	76	54	47	51	78	[c]188+	77	61	40	50	....	100	22	[d]26	[e]132+
		9.0	57	90	59	75	87	66	136+	89	56	90	[f]138+	126+	98	[d]36	188+
		11.1	72	77	77	79	156+	[e][g](202+)	188+	161+	63	103	....	188+	96	48	188+
		12.7	78	66	84	91	188+	[g](228+)	[g](196+)	188	60	85	....	[g](206+)	90	44	188+
O	Open-hearth iron; 0.45 Cu, 0.07 Mo	2.1	38	31	36	44	70	105	48	30	21	33	54	100	6	[d]20	70
		4.0	74	44	38	65	75	84	[e]97	48	28	66	....	116	20	[e]48	55
		9.0	72	85	66	102	102	63	89	97	38	64	[f]242+	174	66	74	80
		11.1	68	81	59	97	125	154	205+	106	55	74	....	243+	70	65	118
		12.7	64	76	51	116	143	145	224+	114	50	64	.....	243+	58	60	140
N	Open-hearth iron; 0.54 Cu, 0.13 Mo	2.1	38	29	36	32	72	132	51	32	20	32	66	77	6	33	50
		4.0	[e]72	51	49	[e]57	76	98	[e]122	44	[e]26	54	.....	100	16	47	74
		9.0	53	92	56	52	70	62	92	102	35	70	[f]171+	162+	68	50	58
		11.1	61	84	65	41	118	137	214+	118	43	78	....	250+	74	66	139
		12.7	59	67	68	44	129	141	179+	71	44	88	....	[g](268+)	54	78	152
J	Copper-nickel steel; 0.95 Cu, 0.52 Ni	2.1	38	34	38	49	60	108	48	26	25	53	63	82	6	14	58
		4.0	57	50	60	60	84	85	82	64	40	63	....	96	15	28	90
		9.0	38	77	69	58	76	67	136	72	57	84	[f]148+	140+	33	40	102
		11.1	63	76	87	67	109	149	180	127	66	112	....	265+	39	48	218+
		12.7	68	72	93	79	132	172+	192	173	60	100	....	[g](280+)	47	50	[d]133
B[h]	Nickel-copper steel; 1.96 Ni, 1.01 Cu	2.1	26	34	51	45	66	38	50	36	20	62	54	100	6	22	64
		4.0	56	52	69	84	88	73	78	52	28	56	....	139	12	25	84
		9.0	45	88	70	75	80	51	142	97	73	80	[f]161+	135	32	37	248+
		11.1	72	70	93	79	[e]128	[e]93	165	107	58	97	....	198+	41	46	164
		12.7	94	74	115	124	102	109	159	98	63	108	....	248+	56	55	138
C	Cr-Si-Cu-P steel; 1.02 Cr, 0.42 Cu	2.1	40	40	36	50	42	56	66	71	23	30	58	52	14	31	58
		4.0	64	51	44	44	70	80	94	52	67	41	....	77	42	41	47
		9.0	45	77	56	86	60	58	148+	98	112+	76	[f]92	84	56	[d]50	58
		11.1	68	79	83	94	86	[e]119+	[g](237+)	110	118	67	....	170+	53	61	147+
		12.7	[e]78	92	88	105	62	128+	[g](278+)	106	107	56	....	188+	64	58	138+
KK	2.01% chromium steel with 0.57 Mo	2.1	40	26	26	56	56	78	102	29	19	31	35	38	22	20	58
		4.0	52	52	56	55	70	130+	94	42	26	35	....	60	27	24	47
		9.0	69	84	58	76	70	80	110	67	57	76	[f]110+	96+	34	41	58
		11.1	66	89	67	67	73	157+	175+	76	67	75	....	175+	48	54	[e]146+
		12.7	48	114	72	70	66	146+	175+	74	71	65	....	[g](183+)	43	56	139+
D	5.02% chromium steel	2.1	43	34	32	37	48	59	87	48	32	30	62	66	18	62	53
		4.0	57	48	52	46	60	99	14	44	51	36	....	95	39	70	68
		9.0	66	70	74	63	62	92	194	64	64	42	[f]114	104	66	108	[e]78+
		11.1	74	66	94	54	87	[e]115	208	60	60	55	....	188	71	118	[e]109+
		12.7	84	56	113	66	154	126	[d]158	68	69	42	....	245+	55	136	81
E	4.67% chromium steel with 0.51 Mo	2.1	36	34	26	39	46	81	79	39	26	26	50	62	20	46	46
		4.0	50	47	46	48	66	88	106	46	36	36	....	80	26	73	57
		9.0	66	51	54	52	46	57	154	56	72	30	[f]86	108+	55	88	48
		11.1	75	49	63	50	76	[e]109+	172+	79	77	35	....	165+	51	86	51
		12.7	98	54	74	70	74	[e]124+	[d]188+	88	74	38	....	188+	46	98	60
H	5.76% chromium steel with 0.43 Mo	2.1	[d]32	30	32	50	46	72	88	48	26	24	64	[d]60	18	[d]42	56
		4.0	57	39	58	56	72	117	94	[d]44	32	32	....	90	33	72	52
		9.0	71	58	56	63	70	76	132+	52	76	[d]38	[f]109	....	64	78	52
		11.1	77	51	65	56	78	141+	196+	....	87	49	....	203+	63	72	48
		12.7	82	54	[d]70	68	90	152+	[d]203+	[d]60	100	44	....	[g](212+)	55	108	55

[a]See table 1 for composition of materials.
[b]See reference (1) for properties of soils.
[c]The plus sign indicates 1 or more specimens contained holes because of corrosion.
[d]Data for 1 specimen.
[e]Data for the individual specimens differed from the average by more than 50 percent.
[f]Average of 8 specimens.
[g]Numbers in parentheses are pit depths adjusted for perforation by multiplying the average penetration by the pitting factor (see text).
[h]The mill scale was not removed from these specimens.

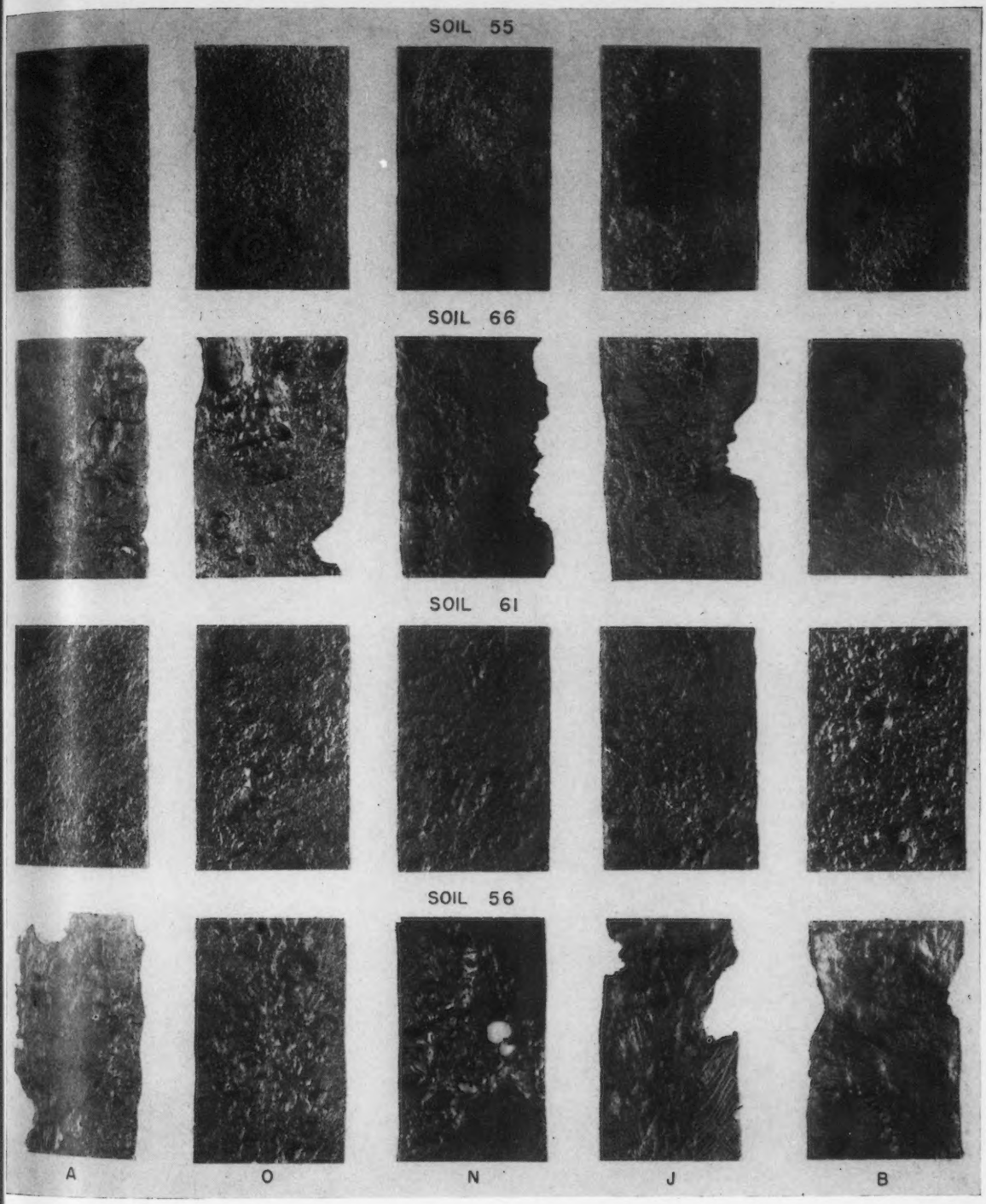


Figure 1—Corrosion of plain steel, copper-molybdenum open-hearth irons and nickel-copper steels in several soil environments. A—Open-hearth steel. O—Open-hearth iron, 0.45 Cu, 0.07 Mo. N—Open-hearth iron, 0.54 Cu, 0.13 Mo. J—Steel, 0.95 Cu, 0.52 Ni. B—Steel, 1.96 Ni, 1.01 Cu. Soil 55, well-oxidized acid silt loam deficient in soluble salts. Soil 66, fairly well aerated alkaline loam containing a high concentration of soluble material. Soil 61, poorly aerated clay containing a moderate amount of soluble material. Soil 56, very poorly aerated heavy clay containing a high concentration of soluble salts.

the alloying constituents induced the formation of corrosion products, which were effective in diminishing the rates of pitting of the alloy steels with time. The results of a previous study of the effect of corrosion products on the rate of pitting of steel[8] suggests a probable explanation for the observed differences in corrosion rate. In that study it was observed that in soils in which the corrosion products of ferrous metal diffused outward into the soil, the rate of pitting changed relatively little with time, but in soils in which the corrosion products

[a]See table 1 for composition of materials.
[b]See reference (1) for properties of soils.
[c]Average of 8 specimens. Numbers in parentheses are pit depths adjusted for perforation by multiplying the average penetration by the pitting factor (see text).
[d]Data for specimens 1 or more specimens contained holes because of corrosion.
[e]The mill scale was not removed from these specimens.
[f]Data for the individual specimens differed from the average by more than 50 percent.

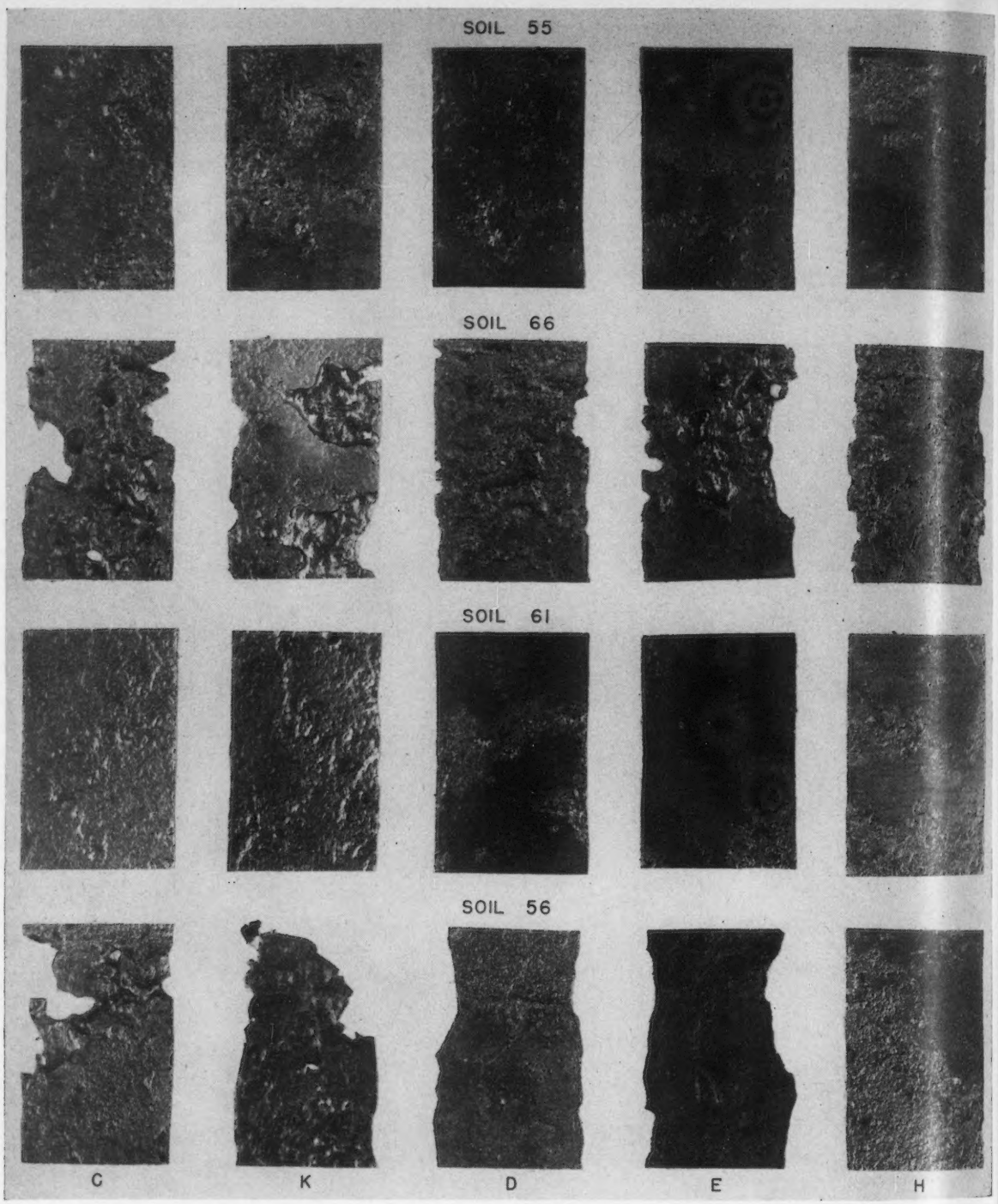


Figure 2—Corrosion of chromium-containing steels in several soil environments. C—Cr-Si-Cu-P steel, 1.02 Cr, 0.42 Cu. K—Steel, 2.01 Cr, 0.57 Mo. D—Steel, 5.02 Cr. E—Steel, 4.67 Cr, 0.51 Mo. H—Steel, 5.76 Cr, 0.43 Cr. Soil 55, well oxidized acid silt loam deficient in soluble salts. Soil 66, fairly well aerated loam containing a high concentration of soluble material. Soil 61, poorly aerated clay containing a moderate amount of soluble material. Soil 56, very poorly aerated heavy clay containing a high concentration of soluble salts.

remained in close contact with the corroding surface, the rate of pitting diminished with time, often becoming negligible after relatively short periods of exposure.

The conclusions that can be drawn from the data in Table IV and Figures 3, 4 and 5 are necessarily limited because these data indicate only the average behavior of the materials under a wide variety of environmental conditions. Whether a particular alloy is more resistant to corrosion than plain steel in a specific soil environment obviously cannot be predicted from these average values. Although the average rates of pitting of the alloy steels decrease more rapidly than the pitting rate

TABLE IV—Calculated Average Values of Weight Loss and Pit Depth After 13 Years of Exposure and Constants of the Weight-Loss and Pit-Depth Equations.

Identification	MATERIAL	WEIGHT LOSS									PIT DEPTH								
		Mean, $\bar{X}$ (Wt.-13 Yr)	Standard Error, $\bar{\sigma}$ (Wt.-13 Yr)	Reduction in Weight Loss as Compared with Control A		t^b	Probability of the Difference Being Due to Chance	k'	$\bar{\sigma}_{k'}$	u	$\bar{\sigma}_u$	Mean, $\bar{X}$ (Pt.-13 Yr)	Standard Error, $\bar{\sigma}$ (Pt.-13 Yr)	Reduction in Maximum Pit Depth as Compared with Control A		t^b	Probability of the Difference Being Due to Chance	k'	$\bar{\sigma}_k$	n	$\bar{\sigma}_n$
				$\bar{X}_1-\bar{X}_2$	Relative Basis									$\bar{X}_1-\bar{X}_2$	Relative Basis						
		oz/ft²	oz/ft²	oz/ft²	Percent		Percent	oz/ft²	oz/ft²			Mills	Mills	Mills	Percent		Percent	Mils	Mils		
A	Open-hearth steel	17.7	1.2					3.76	0.32	0.60	0.07	127	9.3					28.8	4.2	0.58	0.07
O	Open-hearth iron; 0.45% Cu, 0.07 Mo	15.2	1.2	2.5	14	1.47	16	4.79	.75	.45	.06	110	7.0	17.3	14	1.64	12	31.4	2.2	.49	.05
N	Open-hearth iron; 0.44% Cu, 0.13 Mo	15.2	0.8	2.5	14	1.74	10	4.02	.45	.52	.05	112	7.7	25.1	21	2.06	2	33.2	5.0	.44	.08
J	Copper-nickel steel; 0.95% Cu, 0.52% Ni	15.6	.8	2.1	12	1.46	16	3.87	.37	.54	.05	112	10.4	15.3	12	1.09	29	30.8	5.8	.50	.10
B	Nickel-copper steel; 1.96% Ni, 1.01 Cu	17.3	.8	0.4	2	0.30	77	3.93	.25	.58	.03	110	3.6	17.1	13	1.72	10	31.1	2.0	.49	.03
C	CrSi-Cu-P steel; 1.02 Cr, 0.42 Cu	15.3	.6	2.4	14	1.79	10	3.30	.23	.60	.04	107	7.0	20.2	16	1.74	10	29.3	3.9	.50	.07
KK	2.01% chromium steel with 0.57 Mo	12.0	.7	5.7	32	4.10	<1	2.27	.02	.51	.06	93	5.5	33.4	26	3.10	<1	30.3	3.6	.44	.06
D	3.02% chromium steel	10.7	.6	7.0	40	5.22	<1	2.85	.34	.52	.06	100	3.0	24.4	19	2.50	<2	33.5	1.9	.44	.03
E	4.67% chromium steel with 0.51 Mo	10.0	.5	7.7	44	5.92	<1	2.76	.28	.50	.05	86	4.2	41.1	32	4.03	<1	33.0	0.1	.37	.05
H	5.76% chromium steel with 0.43 Mo	10.1	1.6	7.6	43	3.80	<1	2.86	.29	.49	.16	92	6.3	35.0	28	3.15	<1	33.5	4.6	.39	.07

[a] $W = k'T^u$, $P = kT^u$, where W is the weight loss at the time T, and P is the depth of the deepest pit at the time T.

[b] $t = \dfrac{\bar{X}_1 - \bar{X}_2}{\sqrt{\bar{\sigma}_{\bar{X}_1}^2 + \bar{\sigma}_{\bar{X}_2}^2}}$.

of plain steel, it should be recalled that this effect is a consequence of the environment as well as of the material. For example, in a very poorly aerated soil, corrosion products would tend to diffuse and migrate outward into the soil rather than to form protective layers enclosing pits. Under such conditions, the higher initial rate of pitting of the alloy steels would tend to be maintained.

For comparison of the behavior of the materials under different environmental conditions, the corrosion data for the soils classified according to aeration (Tables II and III) were calculated on a relative basis for each material for all periods of exposure, the weight losses and pit depths of the reference steel A being taken as 100 percent. The averages of these values for all periods and for all soils in the same environmental groups are given in Table V. Because the data for soil 51 are incomplete they were not included in calculating the relative values.

The relative corrodibility of the low-alloy irons and steels as measured by weight loss was not affected appreciably by differences in the aeration of the soils. However, the 4 to 6 percent chromium steels were deeply pitted in all of the very poorly aerated soils, except cinders. These steels had higher initial rates of pitting than plain steel, but the rates decreased considerably with time in most of the soils. In the poorly aerated soils, however, this high rate of pitting continued throughout the exposure period, probably because conditions were not favorable to the formation of tubercles, which would have diminished the pitting rate. In contrast is the behavior of these steels in cinders (Table III and Figure 5), where the initial pitting of all the steels was about the same. The pitting of the plain steel continued at a high rate for the entire exposure period, but most of the pitting of the 4 to 6 percent chromium steels occurred during the first 4 years of the test, there being only slight increases in pit depth of these steels after that time. This is even more marked in the case of the steels containing molybdenum in addition to chromium (E and H), in which there was practically no additional pitting after the first 4 years.

Steels containing copper and molybdenum also show more resistance to pitting in cinders after 4 years of exposure than the plain steel, although to a lesser extent than the 4 to 6 percent-chromium steels.

4. Summary

This report contains the results of measurements of corrosion made on several low-alloy irons and steels after exposure to different soils for periods up to 13 years. Empirical equations fitted to weight loss and pit-depth-time curves permitted the initial rates of weight loss and pitting and the change in these rates with time to be evaluated. The general effect of the alloying elements was to reduce the initial rate of corrosion of the alloys as measured by weight loss but to increase the initial rate of pitting. Except in very poorly aerated soils, the rate of pitting of the alloy steels diminished more rapidly with time than the rate of pitting of plain steel, with the result that the maximum depths of pits after the maximum period of exposure were less on the alloy steels than on the plain steels. Chromium was observed to have

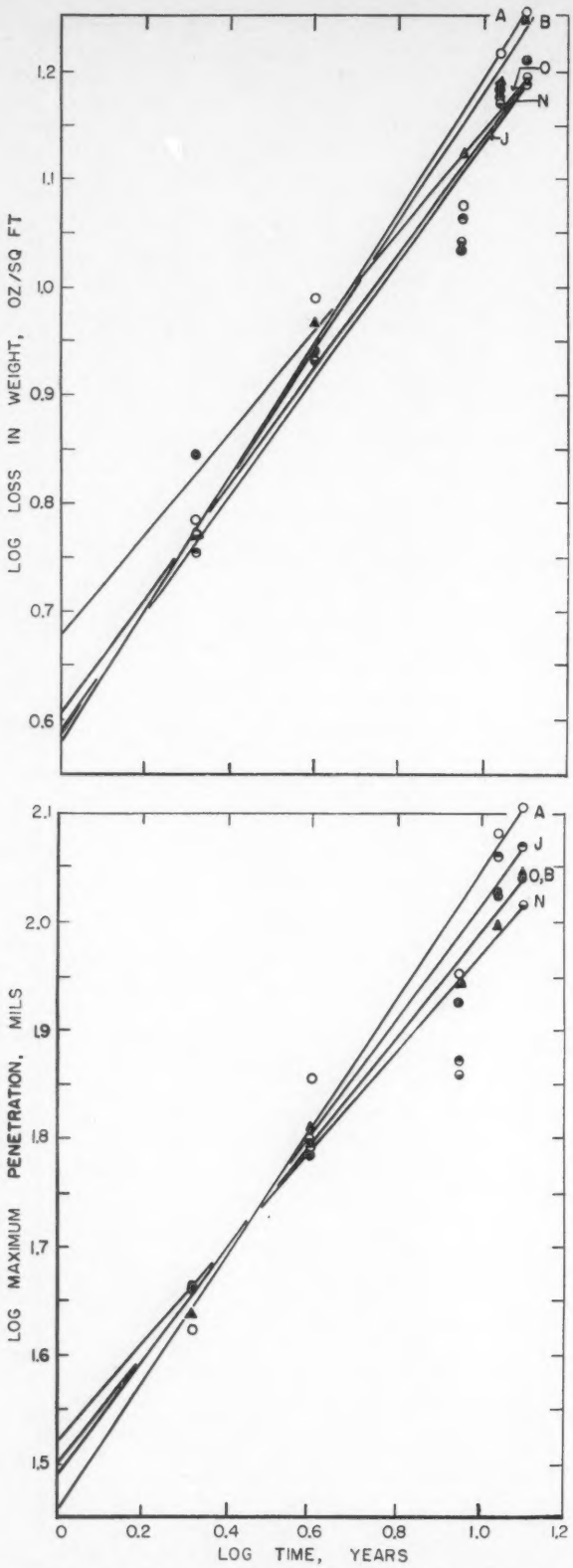


Figure 3—Average loss in weight and maximum penetration-time curves for copper-molybdenum open-hearth irons and nickel-copper steels in 13 soils. A—Open-hearth steel. O—Open-hearth iron, 0.45 Cu, 0.07 Mo. N—Open-hearth iron, 0.54 Cu, 0.13 Mo. J—Steel, 0.85 Cu, 0.52 Ni. B—Steel, 1.96 Ni, 1.0 Cu.

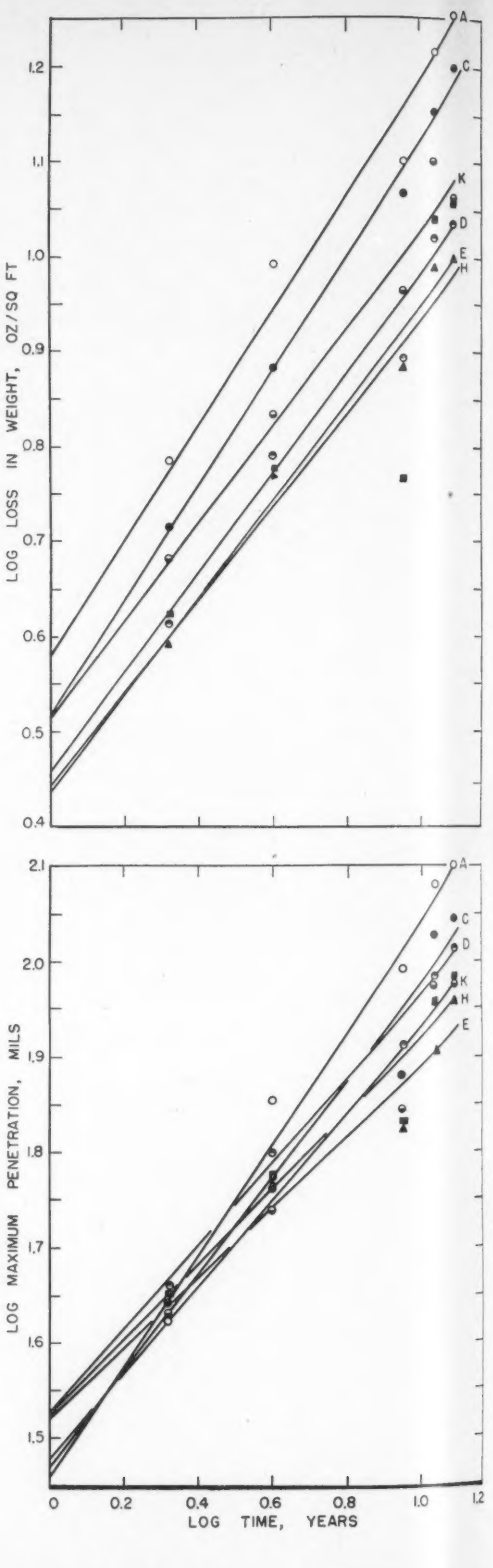


Figure 4—Average loss in weight and maximum penetration-time curves for chromium and chromium-molybdenum steels in 13 soils. A—Open-hearth steel. C—Cr-Si-Cu-P steel, 1.02 Cr, 0.42 Cu. K—Steel, 2.01 Cr, 0.57 Mo. D—Steel, 5.02 Cr. E—Steel, 4.67 Cr, 0.51 Mo. H—Steel, 5.76 Cr, 0.43 Mo.

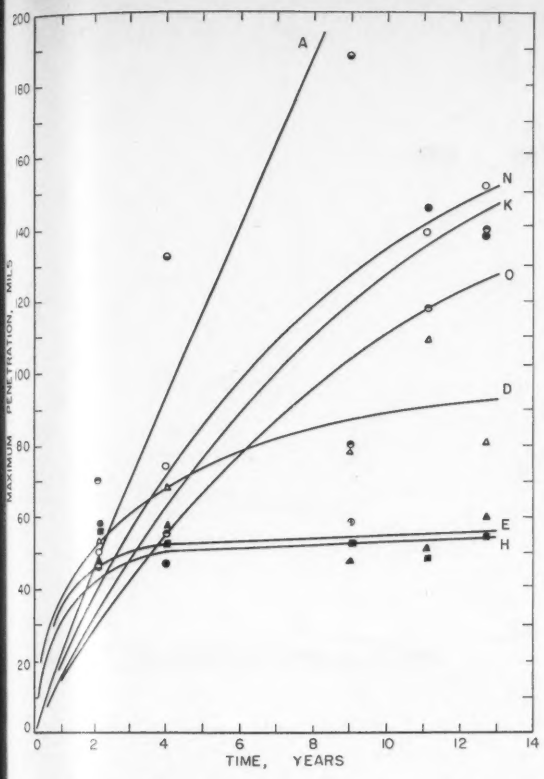


Figure 5—Pit-depth-time curves of copper-molybdenum open-hearth irons, chromium and chromium-molybdenum steels in cinders. A—Open-hearth steel. N—Open-hearth iron, 0.54 Cu, 0.13 Mo. K—2 percent Cr-steel with Mo. D—5.02 percent Cr-steel. E—4.67 percent Cr-steel with Mo. H—5.76 percent Cr-steel with Mo.

the most pronounced effect on weight loss, but for maximum reduction in pitting, molybdenum also was necessary. Chromium and molybdenum were particularly effective in reducing the corrosion of alloy steels exposed to cinders.

The field tests described in this paper were planned and installed, and until 1946 were conducted under the supervision of K. H. Logan.

The writers gratefully acknowledge the cooperation of O. B. Ellis, Research Laboratory, Armco Steel Co. and of C. P. Larrabee, Research Laboratory, United States Steel Co. in making available their equipment for cleaning the specimens by the sodium hydride process.

The authors also gratefully acknowledge the assistance received from the following organizations that cooperate in the project by providing the test sites and the labor required during the installation and removal of the test specimens: Water Department, Charleston, S. C.; Department of Water Works, Atlanta, Ga.; City of Meridian, Meridian, Miss.; New Orleans Public Service Co., New Orleans, La.; Sewerage and Water Board, New Orleans, La.; Gulf Oil Corp., Houston, Tex.; Water Department, Phoenix, Ariz.; Shell Oil Co., Inc., Wilmington, Calif.; Pacific Gas & Electric Co., Bakersfield, Calif.; Union Oil Company of California, San Luis Obispo, Calif.; Milwaukee Gas & Electric Co., Milwaukee, Wis.; City Light & Water Utilities, Kalamazoo, Mich.; Columbia Engineering Corp., Columbus, Ohio; Sinclair Refining Co., Fort Worth, Tex.; Bureau of Water Supply, Baltimore, Md.

References

1. Irving A. Denison and Melvin Romanoff. *J. Research NBS,* **44,** 47 (1950) RP2057.
2. Kirk H. Logan. Underground Corrosion, NBS Circular 450 (1945).
3. H. L. Alexander. *Iron & Steel Eng.,* **24,** 5, 44 (May 1947).
4. I. A. Denison and R. B. Hobbs. *J. Research NBS,* **13,** 125 (1934) RP696.
5. K. H. Logan, S. P. Ewing and I. A. Denison. Symposium on Corrosion Testing Procedures. Am. Soc. Testing Mtls., Philadelphia, Pa. (1937).
6. L. M. Martin. NBS Soil Corrosion Conference 1937 (unpublished).
7. G. S. Eldredge. Section on statistical methods, p. 1083, Corrosion Handbook, (John Wiley & Sons, New York, N. Y., 1948).
8. I. A. Denison. Chemical Aspects of Underground Corrosion and Corrosion Prevention. Monograph, Technical Section, Am. Gas Assn. (1948).

TABLE V—Effect of Composition on the Corrosion of Low-Alloy Iron and Steel Specimens in Soils Classified According to Aeration (Maximum Exposure 13 yrs.)

Identification	Composition of Steel (Percent)				AERATION									
					Good	Fair	Poor	Very Poor	Very Poor Cinders	Good	Fair	Poor	Very Poor	Very Poor Cinders
	Cr	Ni	Cu	Mo	Average Loss in Weight[a]					Average Maximum Penetration[a]				
A	0.049	0.034	0.052	....	100	100	100	100	100	100	100	100	100	100
O	.02	.15	.45	0.07	100	95	98	84	120	100	95	82	120	75
N	.02	.14	.54	.13	100	93	97	83	92	87	96	80	119	63
J	....	.52	.95	....	79	98	94	81	94	96	92	102	93	72
B	....	1.96	1.10	....	79	91	99	81	127	110	81	100	95	72
C	1.02	0.22	0.428	....	94	83	95	76	80	101	84	116	115	64
KK	2.01	.07	.004	.57	90	82	80	63	66	97	91	78	103	60
D	5.02	.09	.008	....	45	77	51	58	55	96	94	83	176	64
E	4.67	.09	.004	.51	46	79	53	56	40	84	83	78	149	54
H	5.76	.17	.004	.43	46	85	52	56	43	88	100	84	149	59

[a] Average for 5 periods of exposure, relative to open-hearth steel (A) =100.

RIGHT AT THE BEGINNING—

Plan on using Bitumastic® Enamel to protect your pipe line against corrosion

ANY pipe line, whether large or small, is an important investment — an investment that should be properly protected.

That's why it's wise, when planning a new pipe line, to include Bitumastic Enamel in your designs, plans and specifications. Bitumastic Enamels, manufactured from selected coal-tars have proved they can prevent corrosion. Many oil and gas pipe lines, that were coated with Bitumastic Enamel and laid 20 and 30 years ago, are still giving good service today.

Why not let your Koppers representative work with you from right at the beginning through final operations? He will be glad to assist you in getting the most out of your protection dollar.

KOPPERS BITUMASTIC ENAMELS
REG. U.S. PAT. OFF.

KOPPERS COMPANY, INC., Tar Products Division, Dept. 404-T, Pittsburgh 19, Pa.

DISTRICT OFFICES: BOSTON, CHICAGO, LOS ANGELES, NEW YORK, PITTSBURGH, AND WOODWARD, ALA.

Topic of the Month

RECENTLY a new series of pipe and fittings has been produced for the handling of corrosive materials. The pipe and fittings are being made from a group of resins comprising polymers of phenolic-butadiene-acrylonitrile which result in a finished copolymer having excellent resistance to many corrosive reagents, and at the same time having extreme toughness and high physical properties.

The unique properties of the material have permitted the manufacture of pipe and fittings in sizes ½-inch to 2-inch, yet capable of working pressures up to 150 psi at 70 degrees F.

Listed below are some of the physical properties of the new resinous pipe.

Specific Gravity	1.07	Maximum Operating Temperature	170° F.
Tensile P.S.I.	5,500	Water Absorption	0.3
Elongation (%)	30	Dielectric Constant	2.9
Hardness Shore D	80	Power Factor	0.05
Modulus of Elasticity	270,000	Thermal Expansion in In./° F.	.000034
Impact Strength Ft. Lb./In. Notch Izod	5		

Thermal Conductivity BTU/Hr./Sq. Ft./° F./In. 1.0

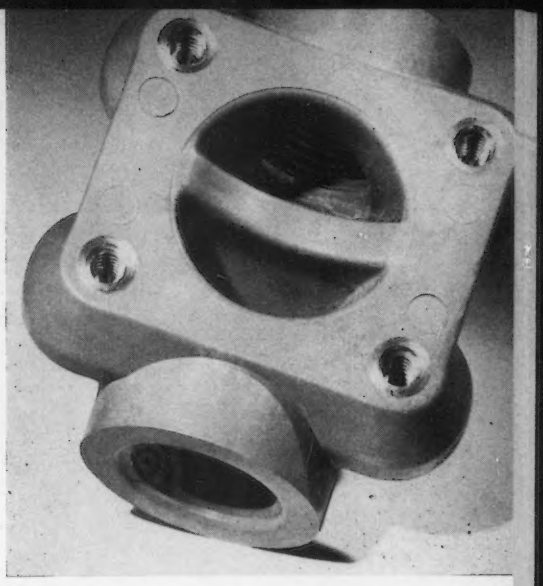


Figure 1—A valve body made of "Uscolite," a product of United States Rubber Company.

Phenolic-Butadiene-Acrylonitrile Polymers for Pipe And Pipe Fittings*

By R. McFARLAND*

The machining and handling properties of this group of resins are excellent so that tubes, slabs or rods of the material can be utilized in standard machining operations and when in the form of pipe can be easily cut and threaded in standard equipment. The pipe and fittings can be assembled in the usual manner with a strap wrench. In making the threaded joints, ordinarily pipe compound or lubricant is suggested to prevent seizing and to facilitate tight joints without excessive wrench pressures. Flanges can be easily assembled onto the pipe standard and acid-resisting rubber gaskets or Teflon gaskets can be used to make up the flanged joint. In making the flanged joint, the bolts should be drawn tight enough to slightly compress the gasket material, but not tight enough to distort the flange.

Within the next few months a complete line of diaphragm valve bodies in sizes ½-inch to 2-inch will be available for companion use with these new resinous pipe and fittings. These diaphragm type valves utilize many types of corrosion-resistant diaphragm materials of either semi-flexible plastics or the usual elastomeric compounds or diaphragms of natural rubber.

These resins are thermoplastic and are not recommended for temperatures of 170 degrees F, nor are they to be used at temperatures below 0 degrees F where such pipe or fittings may be exposed to physical shock or pulsation. Because of the thermoplastic nature of the material, the standard pipe can be easily bent by heating to 220 degrees F and bending around a form of the required radius. In the usual manner the pipe can be filled with sand during the bending operation in order to prevent flattening of the thermoplastic. There is some "spring-back" of the resinous material upon cooling. The pipe should be bent beyond the design radius and then cooled in water while being held in the final desired position.

At normal temperatures there is little inherent sagging or looping. However, as is usual with non-metallic materials of this sort, it is suggested that the line be supported in an angle iron trough or wooden trough. Strap hangers can be used if spaced at intervals of four feet. The pipe can be laid underground without any special precautions beyond those used for metallic pipe or tubing.

The material is non-toxic and satisfactory for handling food products, beverages, deionized water and other equally sensitive materials. Obviously, it is very useful in piping through corrosive or highly humid atmospheres. Its low thermal conductivity reduces its tendency to sweat when handling such materials as cold brine through humid atmospheres.

In general, the material has excellent resistance to the following reagents. For lack of space this is necessarily a shortened list, but the manufacturer of the pipe and fittings has available a very complete listing of the reagents for which these materials can be used.

Acetic Acid (10%)	Kerosene	Sodium Hypochlorite
Alum	Mercurous Nitrate	Sodium Permanganate
Ammonium Hydroxide	Mineral Oil	Sodium Silicate
Calcium Hypochlorite	Nickel Chloride	Silver Nitrate
Copper Chloride	Oil (SAE No. 10)	Stannic Chloride
Fatty Acids	Plating Solutions	Sugar Solutions
Ferric Chloride	Sodium Carbonate	Sulfuric Acid (50%)
Hydrochloric Acid (10%)	Sodium Fluoride	Water, Distilled
	Sodium Hydroxide (20%)	Zinc Chloride

It should not be used for concentrated sulfuric, nitric or chromic acids or high concentrations of hydrogen peroxide. It is also not suitable for ketones and aromatic solvents and it has very limited application in contact with chlorinated hydrocarbons.

★The material described herein is trade named "Uscolite," and is a product of United States Rubber Company.

*Technical Director, Hills-McCanna Company, Chicago, Ill.

NACE News

Kanawha Valley NACE Section Is Organized

Toronto Section Is Organized in Canada

Officers have been named for Toronto Section, first organized in Canadian Region. First meeting of the section, January 26, was attended by 43 persons of whom all but 17 were NACE members.

Officers named for this section are as follows: T. R. B. Watson, Corrosion Service Ltd., chairman; Colin Prescott, Hydro Electric Power Commission of Canada, vice-chairman; R. J. Law, The International Nickel Co. of Canada, Ltd., secretary; Sam Maggiacomo, Anti-Chem, Ltd., treasurer, all of Toronto.

Plans are under way for formation soon of sections of the NACE in Canada at Montreal, Hamilton and Vancouver, according to Hugh P. Godard, of Aluminium Laboratories, Ltd., Kingston, NACE board member.

Domestic Water Supply System Corrosion Is Pittsburgh Topic

R. B. Adams, Superintendent of Purification, Wilkinsburg Penn-Joint Water Authority, Wilkinson, Pa., spoke to members of Pittsburgh Section NACE March 5 on "Corrosion Experienced on Domestic Water Supply Systems." The meeting was held beginning at 8:15 pm at the Conference Room, Mellon Institute, Pittsburgh.

Data on Diaphragms for Valves Covered at St. Louis Meeting

Rolland McFarland, Technical Director of Hills-McCanna Company, assisted by Mr. Kiddle of the same firm presented data on "Valves and Pumps for Corrosive Service," with particular emphasis on diaphragms at the February meeting of Greater St. Louis Section. The dinner meeting was held February 9 at the York Hotel, St. Louis, with 22 members and 16 guests of NACE present.

•

The 1953 spring meeting of South East Region NACE will be held at Hotel Patton, Chattanooga, Tenn., on May 7.

NACE MEETINGS CALENDAR

April

1—Los Angeles Section. Dinner meeting.
1—Southern New England Section.
2—Pittsburgh Section. Metallizing by Howard Vanderpool, metallizing Engineering Company, New York.
14—Houston Section. University night.
21—Cleveland Section. Water Treatment for Corrosion Prevention.
28—Southwestern Ohio Section. Trip through Middletown Division, Armco Steel Corp. Dinner meeting, cocktail Lounge, Manchester Hotel, Middletown, Ohio.

May

7—Pittsburgh Section. Corrosion of Radiant Heating Systems.
8—Philadelphia Section. Poor Richard Club.
12—Houston Section. Founder's Night Program. Kelley's Restaurant, Houston.
19—Cleveland Section. Plant tour, Loisys Brewing Co., Cleveland.
Chicago Section. Round table discussion on protective coatings.
20—Los Angeles Section. Dinner meeting.
26—Southwestern Ohio. Activities at Fernald, by Wm. E. Shaw, department head, National Lead Company of Ohio.

Discussion Session Is Featured at Chicago

Chicago Section NACE held a discussion session moderated by V. Payton at its February 17 meeting at Chicago Engineers' Club. Sixty members and 20 guests were present to participate in the session which featured questions submitted by members.

Next meeting of the section is scheduled April 14.

Atlanta Section Has Discussion Program

At a noon meeting March 2 in Atlanta, the Atlanta Section NACE held a discussion of corrosion problems.

J. Flynn Johnson, chairman, explained the services available from Central Office.

Officers Are Elected By Newly Organized West Virginia Group

The Kanawha Valley Section of Charleston, W. Va., made an auspicious beginning at its first organizational meeting held Feb. 29. With a good crowd of approximately 50 members and guests in attendance, this newest Section in NACE's growing list of new Sections elected officers then saw the film "Corrosion in Action" with comments by T. P. May, of The International Nickel Co., Inc., producers of the film. Mr. May is also chairman of the NACE North East Region.

A. C. Hamstead, Carbide and Carbon Chemical Co., South Charleston, W. Va., was elected Kanawha Valley Section chairman. Other officers elected were, R. I. Zimmerer, Westvaco Chemical Div., Food Machinery & Chemical Corp, South Charleston, W. Va., vice-chairman; Conrad L. Wiegers, Allied Services Co., Charleston, W. Va., secretary; and W. R. Curley, Hope Natural Gas Co., Clarksburg, W. Va., treasurer. Within a few days after the meeting according to Secretary Wiegers, at least six paid applications were received.

Aircraft Corrosion Discussed at Dallas

"Protection of Naval Aircraft Against Corrosion," was the topic of discussion of M. J. Rudick, Supervisor of Non-Metals Engineering of Chance-Vought Aircraft Corp. before North Texas Section NACE March 2. The dinner meeting was held at Dallas.

Rudick

North Texas Section has added eight new members since the first of the year, Miss Maryann Duggan, secretary-treasurer, reported. Attendance at the February meeting was 44.

Committee chairmen have been named as follows by J. C. Spalding, Jr., chairman: H. L. Bilhartz, membership; Charles Stover, entertainment and arrangements; Gene Greenwell, telephone and Kenneth Robbins, publicity.

Southern New England Group Gets Good Start

Guests Outnumber Members 3 to 1 At First Meeting

At the first regular meeting of Southern New England Section of NACE February 4 at New Haven guests outnumbered members 3 to 1. There were 58 guests and 18 NACE members present to participate in interesting business and technical programs presented. A dinner for visiting officers of North East Region NACE and section officers was held preceding the meeting at Hof Brau Haus. The technical and business meeting was held in the auditorium of the Southern New England Telephone Company's administration building.

The business session consisted principally of an account of the organization of the section, an announcement of the next meeting to be held April 1 in the auditorium of the Hartford Gas Company, 233 Pearl St., Hartford, Conn. and a showing of the International Nickel Company motion picture "Corrosion in Action."

Section's History Given

Chairman Frederick R. Meyer of Southern New England Telephone Company, New Haven, Conn., gave a brief account of the organization of the section. He pointed out as especially noteworthy the historical fact that the host organization represented the oldest telephone company in the world, having opened the first commercial exchange in New Haven on January 28, 1878.

Mr. Meyer pointed out further that the first residential telephone of record had been installed on the very site at which the section was meeting, at what was then the family home of Eli Whitney.

Mr. Meyer introduced Ernest A. Johnson, Chief Engineer of the Southern New England Telephone Company and chairman of the General Committees on Electrolysis and Allied Corrosion Activity in the state of Connecticut. This is reputed to be the oldest of such coordinated committees on record. Mr. Johnson welcomed the members and guests and spoke briefly on the advantages and progress of NACE work. Kempton H. Roll, North East NACE Region vice-chairman, extended greetings from the regional board. Frank P. Nettleton, chairman of a Sub-Committee on State Utility Corrosion Problems also responded.

(Continued on Page 6)

Meyer

Tracy

Brophy

SOUTHERN NEW ENGLAND SECTION OFFICERS — Frederick R. Meyer, chairman, Southern New England Telephone Co., New Haven, is a Pratt Institute graduate with 28 years' experience in corrosion work and investigations on telephone plant. He is Plant Analyst in charge of corrosion protection and representative of the Southern New England Telephone Company in joint-utility corrosion engineering problems in Connecticut. Arthur W. Tracy, vice-chairman, has been in the Corrosion Research Laboratory of The American Brass Company since 1923. A Wesleyan University graduate, Mr. Tracy is a long-time member of the NACE Editorial Review Committee and active in NACE affairs. Gerald R. Brophy, secretary-treasurer, in charge of the New England Technical Field Section, Development and Research Division, The International Nickel Co., Inc., Hartford, attended Rensselaer Polytechnic Institute and has been engaged continuously since 1917 in research and metallurgical work.

Is a specialist in LEAD PRODUCTS really a better supplier for YOU?

There is a theory that a man who specializes in mousetraps will build better mousetraps than one who makes merely wood or metal products. This is the narrow view of the self-conscious specialist.

Others say, "Specialists are those who know more and more about less and less," which invites the conclusion that the greatest specialist of all must be he who knows everything about nothing.

Federated believes that the hundreds of products of non-ferrous origin have a basic family resemblance, and that the more we know about all, the more we know about each. Thus lead is found with silver and antimony, and copper and tin are found with iron. These various elements and others must be separated and refined, or in some cases, discarded. Then, re-combined in different ways, sometimes alone, sometimes with other non-ferrous ingredients, they make brass, bronze and aluminum ingot; solders and type metals; die casting alloys, lead products and bearing metals; anodes for plating and for cathodic protection.

Federated's competent organization of scientists and technicians, and its widespread field force of servicemen, are unified under the central policy of producing quality products and making these products most useful to every Federated customer from the one-man shop to the largest plant in the country.

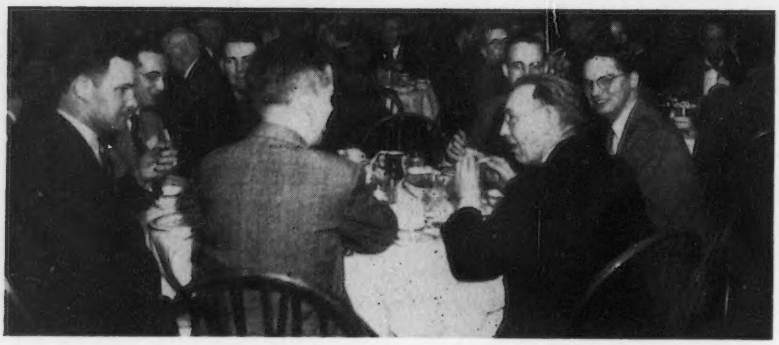
We count it an advantage to our customers that Federated's organization is big enough to specialize in quality control and service from the depths of the mine to the user's shop. It is one of the reasons that Federated is known as "Headquarters for Non-ferrous Metals."

Federated Metals Division
AMERICAN SMELTING AND REFINING COMPANY
120 BROADWAY, NEW YORK 5, N. Y.
In Canada: Federated Metals Canada, Ltd., Toronto, Montreal

Federated first in the non-ferrous field FMD

Aluminum and Magnesium, Babbitts, Brasses and Bronzes, Anodes, Die Casting Metals, Lead and Lead Products, Solders, Type Metals

Microbiology, Inhibitors Topics at Philadelphia



Top photo shows the principal speakers and officers of the Philadelphia Section at the February 13 meeting held at the Poor Richard Culb. Left to right: Paul H. Cardwell, Dowell, Inc., Tulsa, Okla., speaker; E. G. Brink, American Viscose Corp., section chairman; Robert L. Starkey, N. J. Agricultural Experimental Station, speaker; and H. H. Bennett, Socony-Vacuum Oil Co., section vice-chairman. Mr. Cardwell spoke on "Recent Developments in Corrosion Inhibitors," and Mr. Starkey spoke on "Man Against Microbes of Corrosion." Bottom view shows a group at dinner.

At the first meeting in 1953 of the Philadelphia Section, held Feb. 13, at the Poor Richard Club, members heard Robert L. Starkey, research specialist in microbiology, New Jersey Agricultural Experimental Station, speak on "Man Against Microbes of Corrosion," and Paul H. Cardwell, laboratory director of Dowell, Inc. talk on "Recent Developments in Corrosion Inhibitors." T. F. Degnan, program chairman arranged for the speakers.

Briefly, Dr. Starkley sketched the principles of microbiology. "Oxygen, carbon, and potassium cause decomposition of organic and inorganic materials," he stated. "Sulphur, iron, carbon dioxide, nitrogen, and water are important sources of energy.

"Microorganisms live by oxidation which provides energy. In the oxidation process carbon dioxide is usually the end product with ammonia a by-product; also nitrogen is changed to nitrate, alcohol, and methane. This aerobic condition permits decomposition. Fungi grow best at temperatures between 55 and 70°F., and can tolerate a remarkably low pH. Some spores can exist at 150°F. Aerobic and anaerobic conditions create entirely different environments. For instance, coal is formed from peat, whereas oil forms when oxygen has been excluded," Dr. Starkey said.

He listed microbiological corrosion under five general headings:

"1). Acid Corrosion. Is normally caused by sulphuric acid from industrial wastes, mines, or from mud of marine origin. A pH of 3 is not uncommon, and values of 1 and lower have been found. Sulphide changes to sulphate and with deoxidation to sulphur. This can destroy concrete, iron, and steel. Carbonic acid does not normally occur in soils. Nitric acid is seldom of consequence.

"2). Alkali Corrosion. Usually associated with ammonia, is conducive to microbial development. Deterioration of brass condenser tubes is a typical example.

"3). Differential Aeration. Causes oxygen conceration cells to form. In the case of iron microorganisms this accelerates the formation of these destructive cells.

"4). Effect of Microbial Products. Agar contains organic materials, and like other microbiological products, accelerates corrosion. Brass is toxic to microorganisms. Sulphur and copper pass out of the brass into solution at concentrations of 100 to 2000 ppm. Even with copper sulphate at pH 10 and concentrations below 1000 ppm only some organisms are killed—not all. This is the chemistry of many common dyes, germicides, and antibiotic materials.

"5). Anaerobic Corrosion has been known about 20 years. Bacterial growth in the absence of oxygen thrives at pH values between 5 and 9. This growth, and the attendant corrosion, can occur from the release of elementary hydrogen.

"Experience raises the following questions, Dr. Starkey continued: "Why does a depolarizing agent which re-

(Continued on Page 5)

SPECIALISTS IN ALL
RESISTANT PIPING MATERIALS
TO YOUR SPECIFICATIONS
RM RESISTANT MATERIALS
STAINLESS
• PIPE
• FITTINGS
• VALVES
WELDING • SCREWED • FLANGED
SCHEDULES: 5-10-40-80
COMPLETE STOCKS:
ALUMINUM — MONEL — NICKEL
EVERDUR — RUBBER — SARAN
PARIAN — USCOLITE
IMMEDIATE DELIVERY
FULL RANGE OF SIZES
RAY MILLER
254 NORTH 10th STREET, NEWARK 7, N. J.
4240 KANAWHA T'PK., SO. CHARLESTON, W. VA.
1210 HAYS STREET, HOUSTON, TEXAS

Baltimore Section's Meeting Date Set

The Baltimore Section has tentatively set the dates for the rest of 1953. Last meeting until after the summer months is scheduled for April 21. The Section will renew its meetings October 20, and the last meeting of the year is scheduled for December 1.

New officers for the Baltimore Section were introduced at the February 17 Section meeting held at the Park Plaza Hotel, Baltimore, Md. New officers are: L. G. Von Lossberg, chairman; A. L. Alexander, vice-chairman; R. L. Benedict, secretary-treasurer. They were introduced by G. E. Best, chairman, Northeast Region. K. H. Roll, vice-chairman of the Northeast Region, was also present.

Section members saw a movie, "New Weapons Against Corrosion," produced by Knapp Mills, Inc., New York, N. Y. The color film showed details of the firm's process for producing lead clad steel and lead clad copper.

Development of the cladding process from hand-bonding techniques, to a pouring method, and finally an automatic lead cladding machine was shown. Methods of brazing bonded copper joints were depicted along with a variety of finished products including tanks, autoclaves, absorbers and a wide variety of vessels, pipes, joints and valves.

At the end of the movie, Traugott Tschudi, design engineer, and Robert Leonard, Southern manager for the firm answered questions and discussed the process.

North East Region To Meet at Buffalo

NACE Past President Mars G. Fontana will speak on "Corrosion in the Chemical Industry" at the Northeast Regional Meeting to be held in Buffalo, N. Y., May 19 at the Hotel Sheraton. The Buffalo area is closely allied with the chemical industry.

Plans are to have two other speakers discuss protective coatings and environmental treatment in relation to corrosion problems. Each speaker will talk for approximately 45 minutes, each to be followed by a 15-minute question and answer period. The meeting will start at 12:30 with a luncheon and will end about 5:00 p.m.

New York Section Will Hear Talk on Valves

"The Application and Recent Developments of the Hills-McCanna Saunders Patent Diaphragm Valves" will be the subject of a talk by R. McFarland, technical director of the Hills-McCanna Co., at the April 29 meeting of the Metropolitan New York Section to be held at Schwartz's restaurant.

Mr. McFarland will explain the specific adaptabilities of the Saunders valve in controlling the flow of corrosive liquids, according to an announcement by F. J. Lefebvre, Section secretary. The talk will be illustrated by slides. Introductory remarks will be made by R. T. Kidde, general sales manager of Hills-McCanna.

Galvanizers Committee

The Galvanizers Committee, which is sponsored by the American Zinc Institute will hold its 29th meeting in St. Louis April 27-28 at Hotel Statler.

Microbiology, Inhibitors—

(Continued From Page 4)

moves hydrogen permit corrosion to proceed? This seems to occur more rapidly in sea water than in soil. Do large quantities of oxygen in sea water lessen corrosion?"

Explaining further, Dr. Starkey said, "In tests made on steel pilings in sea water various effects can be observed above water, submerged, in the mud line, and below the mud line. Corrosion is greatest below the mud line where the corrosion products slough off and repeatedly reform.

"The two major means of protection against anerobic corrosion are: (a) Perfect insulation, and (b) Inhibition by toxic materials, while heat sterilization may stop anaerobic corrosion, it is difficult to accomplish. Some few inhibitors are effective, but in time bacteria develop resistance to them. Corrosion will not occur in water completely free of bacteria.

"Insulation is effective against bacteria as well as currents. Protective insulation plus cathodic protection is the best system yet developed. Little is known about why bacteria corrodes lead except that the sulphide is microbial in origin. Some type of bacteria will even attack asphalt. One fact is outstanding—a sulphur media is important for corrosion to continue. This is best evidenced by the action of sulphuric acid and the anaerobic condition in sulphide muds."

In his talk on inhibitors, Dr. Cardwell told the group that recent laboratory tests were conducted to evaluate the effects of certain inhibitors for use in oil field and oil well equipment with the following results:

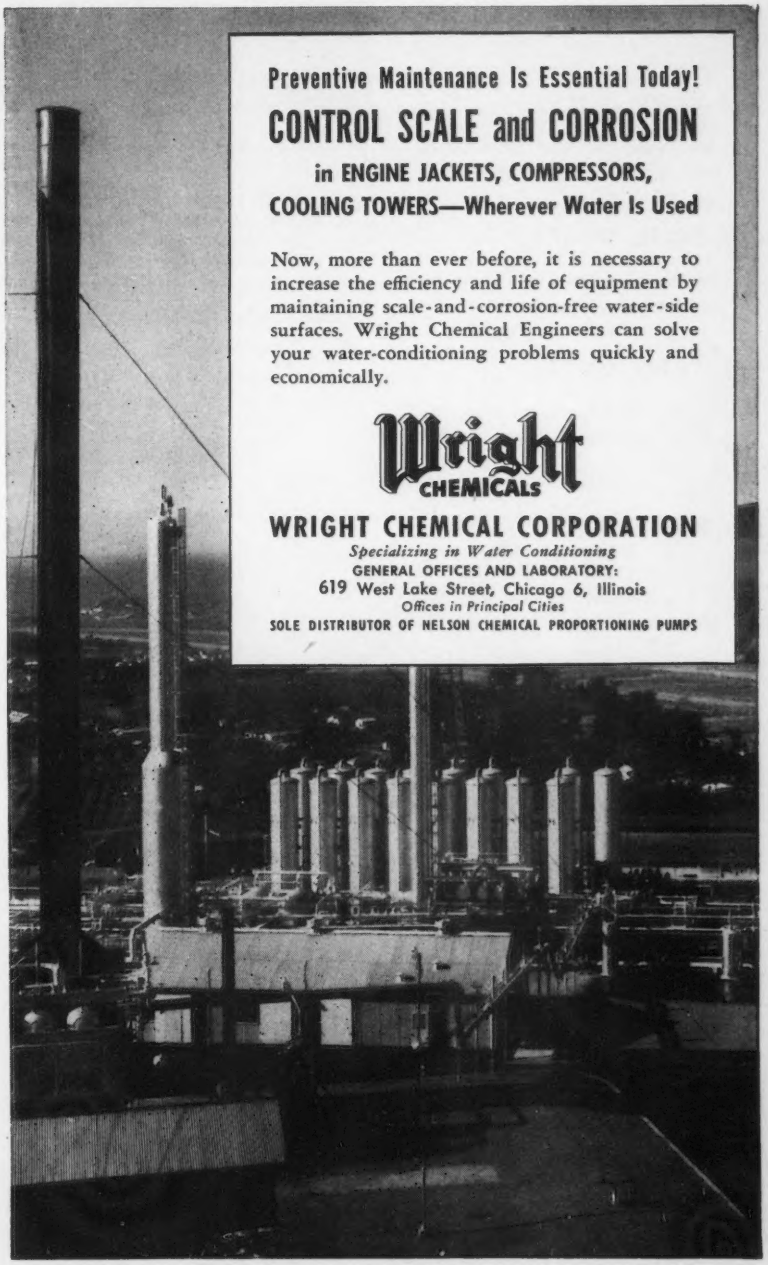
"1) Coal tar base inhibitors. Annealing the metal reduces the grain size which in turn reduces corrosion. One laboratory technique mentioned was that the higher the magnification required to resolve the pearlite, the more difficult it was to control corrosion.

"2) Coal tar base with thiourea inhibitor was found to be most effective.

"3) Coal tar base and polyethanol amine inhibitor were tested using boiler hand hole plates made up into special cylinders and immersed in a hydrochloric acid solution. Again it was established that the corrosive action was greater in areas of the coarser grains, and that the effect of this inhibitor could be measured.

"4) Synergistic effect in using 50 ppm thiourea and 50 ppm amine proved substantially better than using 100 ppm of either.

"Results of these tests indicated that thiourea is a better inhibitor than coal tar; and that the coal tar base inhibitors are better than polyethanol amine inhibitors in removing the hydrogen that causes corrosion in the oil well equipment," he said.


Preventive Maintenance Is Essential Today!
CONTROL SCALE and CORROSION
in ENGINE JACKETS, COMPRESSORS,
COOLING TOWERS—Wherever Water Is Used
Now, more than ever before, it is necessary to increase the efficiency and life of equipment by maintaining scale-and-corrosion-free water-side surfaces. Wright Chemical Engineers can solve your water-conditioning problems quickly and economically.
Wright
CHEMICALS
WRIGHT CHEMICAL CORPORATION
Specializing in Water Conditioning
GENERAL OFFICES AND LABORATORY:
619 West Lake Street, Chicago 6, Illinois
Offices in Principal Cities
SOLE DISTRIBUTOR OF NELSON CHEMICAL PROPORTIONING PUMPS

PLA-TANK® DUCTS

are the answer where corrosion is a problem

PLA-TANK DUCTS

are manufactured from long-life resin-bonded glass fiber.

PLA-TANK DUCTS

are resistant to a wide variety of fumes.

PLA-TANK DUCTS

are resistant, inside and out, at temperatures from -60° F. to 280° F.

PLA-TANK DUCTS

are competitively priced with other corrosion-resistant materials.

PLA-TANK DUCTS

are available now in standard 6"—54", as well as rectangular and custom-built shapes, including hoods.

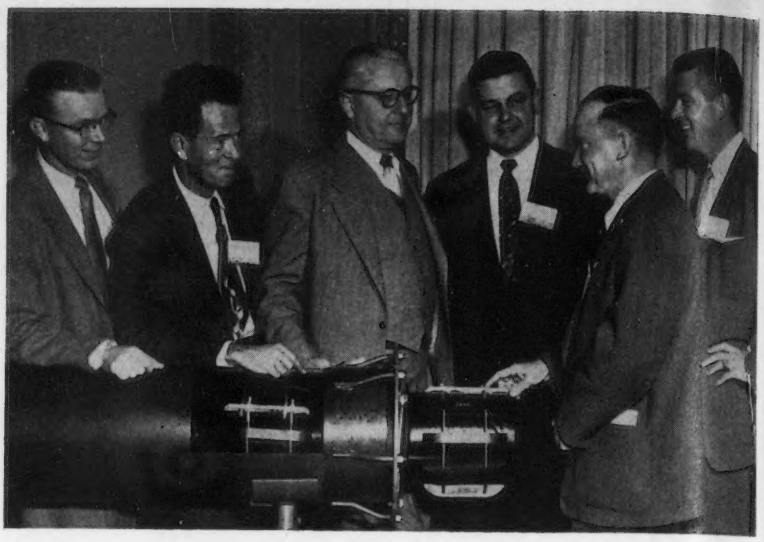
PLA-TANK DUCTS

are the answer to your needs for many fume exhaust jobs now on your drawing boards —or for replacements in existing systems.

Write for free data file sheet

THE Chemical CORPORATION

65 Waltham Ave., Springfield 9, Mass.



Instructors for the Tulsa Short Course, each an authority in his field, are attentive while a fellow teacher has the floor, The short course, Practical Control of Pipe Line Corrosion, was held March 4-6. Shown here left to right are: R. M. Ragland, Phillips Petroleum Co., Bartlesville; Marshall Parker, Cormit Engineering Co., Houston, Tex.; F. M. Hieronymus, Barrett Div., Tulsa, Okla.; L. F. Heverly, Great Lakes Pipe Line Co., Kansas City; F. M. Cloninger, Texas Pipe Line Co., Tulsa, Okla.; and T. L. Canfield, Consolidated Gas Utilities, Oklahoma City. Not present when the picture was taken: Y. W. Titterington, Pipeline Anode Corp., Tulsa, Okla.

Guests Outnumber–

(Continued From Page 3)

Committee Heads Named

Names of section committee chairmen were announced as follows: A. W. Tracy, American Brass Company, Waterbury, meetings and program; H. M. Johnquist, Bristol Company, Waterbury, publicity; L. M. Rasmussen, Manning, Maxwell and Moore, Stratford, social; A. T. Steeves, Electric Boat Company, New London, reception; A. M. Plant, United Illuminating Co., New Haven, and A. B. Hamilton, Hartford Gas Company, membership.

Mr. Meyer also reported on a meeting of North East Region's board January 20 when the section was honored by appointment on a committee to standardize section regulations and by-laws. The section also plans to survey the status of corrosion courses and allied studies in educational institutions in the vicinity.

Motion Picture Shown

Thomas P. May, International Nickel Co., Inc., New York City, have interesting preliminary data on corrosion prior to and during the showing of the Inco motion picture "Corrosion in Action."

C. J. Vander Valk of Lead Industries Association will talk on "Metal Protective Paints" at the next meeting of the section. The meeting, to be held beginning at 8 pm on April 1, will be held at Hartford Gas Company's auditorium, 233 Pearl St.

"Metal Protective Paints" was the title of the talk scheduled for the April 1 meeting of the Southern New England Section. C. J. Vander Valk, technical director of the Pigment & Chemical Div. of the Lead Industries Association, New York, N. Y., was the speaker. The Hartford Gas Co. auditorium was selected for the meeting.

Over 200 Pipeliners Attend Short Course

More than 200 pipeliners from all sections of the U. S. attended the fourth annual 3-day Tulsa short course for Practical Control of Pipe-Line Corrosion which closed March 6th with field demonstrations and a question-and-answer session.

Sponsored by the National Association of Corrosion Engineers as in past years, the school attracted several pipeliners from Ontario and Alberta, Canada, and one from Monterrey, Mexico.

In the opinion of W. A. Hutchison, Sinclair Pipe Line Co. engineer who was in charge of the short course, the practical aspect of corrosion control was clearly emphasized by each instructor in explaining the latest methods, materials and equipments employed by the industry.

Shown in the photo, left to right: T. M. Ragland, Phillips Petroleum Co., Bartlesville, Okla.; Marshall Parker, Cormit Engineering Co., Houston, Tex.; F. M. Hieronymus, Barrett Div., Tulsa, Okla.; L. F. Heverly, Great Lakes Pipe Line Co., Kansas City, Mo.; F. M. Cloninger, Texas Pipe Line Co., Tulsa, Okla.; T. L. Canfield, Consolidated Gas utilities, Oklahoma City, Okla. Not shown, Y. W. Titterington, Pipeline Anode Corp., Tulsa.

•

Manuscripts on subjects dealing with Corrosion from any source are considered for publication in Corrosion magazine. The association, in general, prefers not to publish material which has appeared in other readily available periodicals, or which consists solely of an advertising sales message. Copies of the NACE "Guide for the Preparation and Presentation of Papers" are available on request.

Lay sour crude pipe with 62% less labor cost

Easy-handling Tenite pipe means substantial installation economies. In a typical case, three men laid 4000 feet of 4" Tenite pipe a day; eight men are usually required to handle the same amount of steel pipe.

Extruded of Eastman cellulose acetate butyrate plastic, Tenite pipe does not corrode under oil-field conditions. Major oil producers are successfully using it for sour crudes, salt water disposal, and in areas where electrolytic action affects steel pipe.

Because of Tenite's extra-smooth walls, paraffin has never clogged a Tenite pipe line. For any given head loss Tenite pipe also delivers approximately 40% more fluid than clean steel pipe of the same diameter.

Pipe extruded of Tenite is made by various companies to which Eastman supplies the plastic compound. Send the coupon for further information about Tenite plastic pipe. If you need assistance in adapting Tenite pipe to your operation, our technical staff will be glad to help.

For corrosion resistance ask for PIPE MADE OF–

TENITE

an Eastman Plastic

• EASTMAN CHEMICAL PRODUCTS, I

Sales representative for

TENNESSEE EASTMAN COMPANY

Division of Eastman Kodak Company

KINGSPORT, TENNESSEE

EASTMAN CHEMICAL PRODUCTS, INC.

DEPT. 2, KINGSPORT, TENNESSEE

Please send me further information about TENITE PLASTIC PIPE

NAME.....

TITLE.....

COMPANY.....

STREET.....

CITY.....STATE.....

Pittsburgh Election Scheduled on May 7

May 7 has been set as election day for officers of the Pittsburgh, Pa., Section.

Approximately 50 Section members attending the March 5 meeting held in the conference room of the Mellon Institute in Pittsburgh, Pa., learned of "Corrosion Experienced on Domestic Water Supply Systems." R. B. Adams, superintendent of purification, Wilkinsburg Penn-Joint Water Authority, Wilkinsburg, Pa., was the speaker. Mr. Adams has had years of experience in domestic water supply systems.

Central Oklahoma Section Elects New Officers

New officers took over management of Central Oklahoma Section January 1. They are: Dan H. Carpenter, Sohio Petroleum Co., chairman; Martin L. Steffens, Oklahoma Natural Gas Co., vice-chairman; Bruce D. Owen, Southwestern Bell Telephone Co., secretary-treasurer, all of Oklahoma City. F. W. Fullerton, Southwestern Bell Telephone Co., was named section trustee.

R. E. McMinn of Black, Sivalls and Bryson, Inc., spoke to section members at the January 28 meeting on the topic "Corrosion in Oil and Gas Processing Equipment," and Clyve C. Allen of Anderson-Prichard Oil Corp. spoke on "Asphaltic Protective Coatings," at a February 25 meeting. Both meetings were held at Oklahoma City YMCA.

•

Lists of material published for resale by NACE may be obtained by writing to Central Office 1061 M. & M. Bldg., Houston 2, Texas.

John B. West Elected South East Region Chairman for 1953

John B. West, Aluminum Co. of America, Atlanta, has been elected chairman of NACE's South East Region for 1953, moving up from the vice-chairmanship. At the same time H. C. Van Nouhuys, Southeastern Pipe Line Co., Atlanta, formerly region secretary-treasurer became vice-chairman while David L. Chadwick, Monsanto Chemical Company, Anniston, Ala., was elected secretary-treasurer.

Also named were E. D. Vines, Koppers Co., Inc., Woodward, Ala., chairman of the publicity committee and J. Frank Putnam, Anti-Corrosion Mfg. Co., Atlanta, chairman of the membership committee.

North Central Election Ballots Are Mailed

Letter ballots were sent out in March for election of a director for the North Central Region to serve a three-year term beginning with the last day of the NACE 1953 Conference and Exhibition.

The Region nominating committee nominated Walter R. Cavanagh for the office. Ballots were to be mailed to Norman A. Kerstein, 16817 Robson, Detroit, Mich.

•

Indices to each volume of Corrosion are published in the December, the twelfth and last issue of each year.

Shown here is Mars G. Fontana, past president of NACE as he addressed members of the Detroit Section of NACE and of the Electrochemical Society in a joint meeting held in Detroit, Mich., Feb. 19 at the Engineering Society of Detroit. More than 100 persons attended the dinner meeting. In expressing his appreciation for Dr. Fontana's appearance, L. D. Cook, Detroit Section chairman said he expected several applications for membership would be received and that future Section meetings would profit by larger attendance and more enthusiasm.

M. G. Fontana Speaks at Los Angeles Meeting

M. G. Fontana of Ohio State University, NACE president, addressed members of Los Angeles Section at Rodger Young Auditorium, Los Angeles, February 5. His subject was "Corrosion and Its Prevention."

Dinner meetings of Los Angeles Section have been scheduled for April 1, May 20 and September 16.

South East Region Will Meet on May 7 At Chattanooga

NACE members attending the Southeast Region meeting to be held May 7 at Hotel Patten in Chattanooga, Tenn., will hear three outstanding speakers, according to a telegram received by E. P. Tait.

Frank Whitney, Monsanto Chemical Co., will speak on austenitic stainless steels; M. E. Flentje, American Water Works Service, Inc., will talk on water corrosion problems; and R. Wray, Aluminum Company of America, will speak from 30 years experience in the protective coating field and in corrosion problems in the textile industry.

Sidney A. Gibson of Tennessee Coal, Iron and Railroad Company, Fairfield, Ala. will present a paper "Electrolysis in Mine Trolley Systems."

•

Information on NACE's Corrosion Abstract Card Service may be obtained by writing to Central Office, 1061 M. & M. Bldg., Houston 2, Texas.

NOMINATIONS FOR 1954 NACE AWARDS

Should Be Made Not Later Than July 1

The Procedure for the Selection of Persons to Receive the Willis Rodney Whitney and Frank Newman Speller Awards in 1954 as approved by the Board of Directors in Galveston, March 14, 1952, provides for nominations being made by a local section or by an individual member directly to the Chairman of a Region. All nominations should be accompanied by an appropriate statement of the basis of the proposal.

This Procedure requires that prior to July 1, 1953, the Regional Chairman shall forward to the Chairman of the Awards Committee all names proposed for awards, accompanied in each case by summaries of the reasons presented in support of each proposal, but with no indication of the number of duplicate nominations of any individual. The object of this latter provision is to insure that awards will be made on a basis of accompishments and other qualifications rather than by any semblance of a popular vote.

The Procedure also requires that the NACE membership be notified of their privileges with regard to nominating candidates for these awards either by direct letter not later than May 1, 1953, or through publication in the May, 1953 issue of CORROSION. A direct letter is not contemplated; hence, this notice as it appears in this issue of CORROSION Magazine will serve as the notification to the NACE membership that nominations for these two awards may be made to their respective Regional Chairman not later than July 1, 1953. Reference to the Regional Division map on page iv and the Directory of Regional and Sectional Officers on pages iv and v of this issue will enable any member to obtain the name and mailing address of the regional chairman to whom his nominations should be sent.

Johns-Manville TRANTEX *polyvinyl* TAPE

gives lasting protection against pipeline corrosion!

ON JOB AFTER JOB, Johns-Manville Trantex Tape is controlling corrosion and extending the service life of underground gas and oil pipelines.

Trantex is a durable plastic tape that sticks on contact—bonds tightly to the pipeline. No heat or heavy duty equipment is needed in its application. It is easily applied by hand or by specially developed hand-operated machines. Many users have found that field-applied Trantex Tape speeds coating applications . . . lowers construction costs on both large diameter transmission lines and gas distribution systems.

Trantex Tape is a development of Johns-Manville—a pioneer in the manufacture of Asbestos Pipeline Felts. For further information about Trantex Tape, write for copy of PP-26A, Johns-Manville, Box 60, New York 16, N. Y.

	*V-10	**V-20
Dielectric Strength per mil thickness, Approx.	1,000 V	1,000 V
Insulation Resistance, greater than (ASTM-D-257-49)	100,000 megohms	100,000 megohms
Temperature Limit	200 F	200 F
Adhesion oz. per inch width	30	20
Tensile Strength lbs. per inch	30	56
Elongation at Break	250%	300%

"Trantex" is a black polyvinyl tape. It is available in two thicknesses—

*V-10 is a 10 mil tape for average conditions, and

**V-20 is a 20 mil thickness for use where a more rugged coating is specified, such as to repair enamel coatings.

JM JOHNS-MANVILLE PRODUCTS

Johns-Manville TRANTEX *polyvinyl* TAPE

PROTECTS PIPELINES AGAINST CORROSION

Stress Corrosion Is Houston Section Topic; New Officers Named

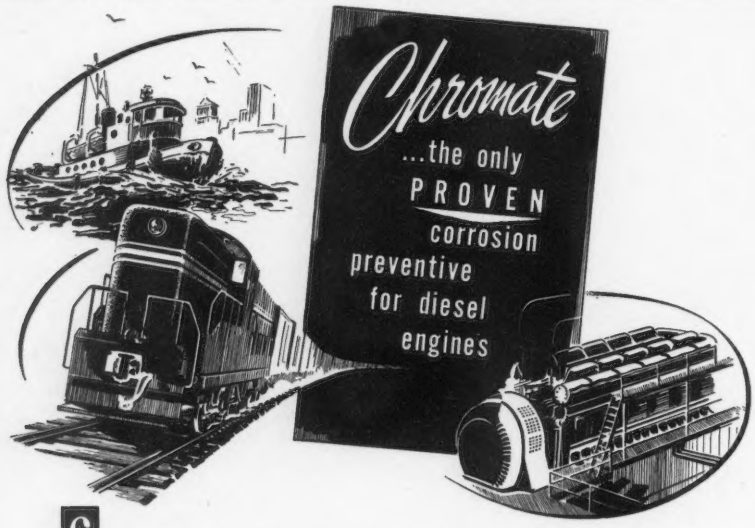
S. E. Doughty of Carpenter Steel Company spoke on "Stress Corrosion Cracking of Stainless Steels" at the February 10 dinner meeting of Houston Section at Kelley's Restaurant, Houston. A lively discussion followed Mr. Doughty's talk. There were present 95 members and guests.

New officers who assumed control of the section in March were named as follows: L. G. Sharpe, Humble Pipe Line Company, chairman; J. A. Caldwell, Humble Oil & Refining Co., vice-chairman; R. C. Booth, Shell Oil Company, secretary-treasurer. Charles G. Gribble, Jr., of Metal Goods Corp. was named representative on the Houston Engineers' Council for a two-year term. Also elected as alternates to Mssrs. Gribble and Caldwell on the engineers' council were John E. Loeffler, Thornhill-Craver Company and A. L. Stegner, Tennessee Gas Transmission Co. Mr. Caldwell is presently representative on the engineers' council with one more year to serve.

Results of the election for officers were given by Charles Scamman, of the tally committee, who reported 175 ballots cast.

•

The Tenth Annual NACE Conference and Exhibition will be held at Kansas City in March, 1954.



CHROMATES are the only tried and true answer to controlling cylinder-liner corrosion in diesel engines. Use of chromium inhibitors is universally accepted by locomotive builders.

Sodium chromate stops corrosion before it starts. The presence of this one chemical renders the metal surface passive to corrosive attack. Slight oxidizing action occurring upon initial contact produces an additional safeguard—a protective surface-deposit of iron and chromium oxides.

Diesel locomotives require only 2000 to 2500 ppm sodium chromate at pH 8.5 to 9.5 to minimize the combined effects of vibration and corrosion. Other units such as standby boilers, stationary and marine diesels, hot water heating systems, and automobile radiators vary in their anti-corrosive requirements from 200 to 5000 ppm sodium chromate. It is important that sufficient chromate concentration be maintained at all times; to leave valuable equipment unprotected even for short periods may result in serious damage.

Mutual, the world's largest manufacturer of chromium chemicals, supplies the chromates necessary for cooling systems protection. Information about corrosion prevention in all types of cooling systems will be sent upon request.

SODIUM CHROMATE • SODIUM BICHROMATE
CHROMIC ACID • POTASSIUM BICHROMATE

SINCE 1845

Mutual Chemical Company of America

270 Madison Avenue, New York 16, N. Y.
Plants at Baltimore and Jersey City

Jack T. Martin Elected New Orleans-Baton Rouge Section's New Chairman

Jack T. Martin of The Texas Company has been named chairman of the New Orleans-Baton Rouge Section. Other officers named were Frank S. Bird, The California Co., vice-chairman, and Russell W. Schutt, Shell Oil Company, secretary-treasurer.

F. L. LaQue Heard at Houston Section Meeting

Frank LaQue was the speaker and the steaks were good. This combination made the March meeting of the NACE Houston Section an enjoyable one. The meeting was held jointly with the Texas Chapter of the American Society for Metals.

Results of the Houston Section election were announced by Charles Gribble, retiring Section chairman. L. G. Sharpe, Humble Pipe Line Co., was elected chairman: J. A. Caldwell, Humble Oil & Refining Co., vice-chairman and R. C. Booth, Shell Oil Co., secretary treasurer.

"Some Effects of Heat Treatment of Metals on Their Resistance to Corrosion" was his topic, and Mr. LaQue drew on his 27 years of research on corrosion to draw attention to some ways by which heat treatment may affect resistance to corrosion either favorably or unfavorably. The talk was illustrated with many slides.

In addition to being an acknowledged expert in his field, Mr. LaQue is an accomplished speaker with a good sense of humor. He held the attention of his audience.

One of the points Mr. LaQue made in his talk is that the potential difference between the underlying steel and the attached mill scale may amount to as much as 600 millivolts depending on the temperature of scale formation. This is a greater difference of potential than exists between copper and steel in salt water, he pointed out. It is therefore often desirable to descale steel as a means of preventing pitting. The U. S. Navy specifies the descaling of steel for ships to eliminate this localized, galvanic corrosion, Mr. LaQue stated.

One of the interesting puzzles of corrosion was pointed out by Mr. LaQue. In a comparison of specimens of carburized steel and nitrided steel exposed to salt water, it was found that the small lathe marks made in the specimens by machine tools corroded badly in the nitrided specimens. The same lathe marks did not corrode preferentially in the carburized steel. The puzzling thing is that the lathe marks were made before any nitriding was done.

The effect of inadequate quenching associated with efforts to avoid weld decay of stainless steels was also described by Mr. LaQue. In many instances, instead of improving the weld area, the entire piece has been ruined, he pointed out.

Careful heating for stress relief plus proper cooling will help in preventing stress corrosion, Mr. LaQue pointed out. However, on the basis of potential difference, there is usually little difference in electric potential between stressed and unstressed metal due simply to energy effects within the range of elastic deformation. Consequently, there is little

(Continued on Page 23)

Stewart to Discuss Well Corrosion at Shreveport Section

Shreveport Section members of the NACE will hear talk on "Oil and Gas Well Corrosion," by W. H. Stewart of the Sun Oil Co., Beaumont, Tex. at the April 21 meeting at the Caddo Hotel.

May 19, Sidney E. Trouard, New Orleans Public Service Co. will address Shreveport Section members. His subject will be: "Corrosion Experiences of Steel and Cast Iron Pipe in the New Orleans Area."

The June 16 meeting will hear R. L. Bullock of Interstate Oil Pipe Line Co., Shreveport, La. The subject Mr. Bullock will talk on will be announced later, according to W. F. Levert, Section chairman. All of the meetings will be held at Shreveport's Caddo Hotel. Meetings are held the third Tuesday of each month.

Teche Section Hears Edwards on March 10

Teche Section NACE members attending the March 10 meeting heard W. H. Edwards discuss: "Mechanics of Treating in Control of Oil and Gas Well Corrosion." Mr. Edwards is corrosion engineer for the Superior Oil Co., Houston, Tex. After the talk, Joseph H. Waterfield, Section secretary reports "there was a brisk discussion period and many individual problems and solutions developed."

The meeting was held March 10 at Jacob's Four Corner restaurant, Lafayette, La.

New Coating Is Topic At Corpus Christi

"A New Method of Corrosion Control—Demitcote," by Robert A. Steel, Jr. of Allen D. Stafford, Inc., Amercoat distributor, was the subject scheduled for discussion at the Corpus Christi March 24 meeting at the Corpus Christi Engineers Club: "Demitcote" is described as a "cold zinc application."

Arrangements were made for a turkey dinner with all the trimmings, with a half-hour fellowship period preceding the combination dinner and technical meeting.

North Texas Section To Have Ladies' Night

It will be "Ladies Night" at the last meeting of the season for the North Texas Section of the NACE, according to J. S. Spalding, Jr., Sun Oil Co., Dallas, Tex., Section chairman. The meeting will be held in Dallas and will have a speaker from "Facts Forum," Mr. Spalding stated.

Scheduled as the principal speaker for the April 6 meeting in Fort Worth, Tex., was W. M. Thornton of the Atlantic Refining Co. Laboratory, his topic: Lab Testing and Field Usage of Plastic Tubular Goods.

PROOF

HERE'S HOW TAPECOAT® HAS STOOD THE TEST OF TIME TO SOLVE CORROSION PROBLEMS

PROOF (Underground) — Inspection of TAPECOATED joints after 10 years of underground service showed no sign of corrosion when the TAPECOAT was removed.

PROOF (Alternate wetting and drying) — Expense and trouble in protecting lines subject to wet and dry conditions at cooling towers have been eliminated since 1944 by coating with TAPECOAT.

PROOF (Underwater)—During the re-laying of an underwater pipe line in the Gulf area, examination showed that TAPECOAT had protected the pipe against salt water corrosion and barnacles.

PROOF (Above ground)—A gas line at a bridge crossing was TAPECOAT-protected in 1944. There has been no need for attention and *no interruption of service* since the pipe was TAPECOATED.

Actual experiences like these show what TAPECOAT coal tar protection can do for you.

Use TAPECOAT to combat corrosion above or below ground on gathering lines, transmission lines, meter stations, compressor stations, distribution lines, pipe joints, bolt-type couplings, fittings, large bends, large diameter pipe, insulated lines, tanks, and other surfaces subject to corrosion.

Write for descriptive brochure and prices

The* TAPECOAT *Company

Originators of Coal Tar Tape Protection

1521 Lyons Street, Evanston, Illinois

San Francisco Section Has Short Course Teachers as Guests

When the University of California at Berkeley presented the Corrosion Short Course, the San Francisco Section secured top flight speakers for their Section meeting, Feb. 3, at the Alouette restaurant. A number of persons, authorities on corroson who presented papers at the Short Course, attended the Section meeting as guests. Among them were Mars G. Fontana, then President of NACE, who spoke briefly on the objectives and accomplishments of the Association.

The technical address by Norman Hackerman of the University of Texas reviewed recent developments in corrosion research including new techniques in the determination of polarization curves and solution potentials. He also reviewed work done in the University of Texas laboratories using vacuum techniques to determine oxidation rates and incubation time for formation of stable oxides on various metals.

According to D. Roger Loper, Section vice-chairman, "The address was enthusiastically received by the largest group in attendance at a local Section meeting for some time."

●

Reprints of material published in Corrosion are usually made only on order. Tentative prices may be obtained from Corrosion, 1061 M & M Bldg., Houston 2, Texas.

San Diego Section's Organization Pushed

NACE's fledgling, San Diego, California Section, has been organized. Officers have not yet been elected, but the responsibility of putting the new section in good working order has been accepted by L. E. Magoffin as acting Chairman and D. G. Raasch as acting Secretary-Treasurer. Mr. Magoffin is associated with the California Water and Telephone Co. Mr. Raasch's company affiliation is with the La Mesa Lemon Grove, Spring Valley Irrigation District.

Thirteen members form the nucleus of the Section, and Mr. Magoffin states approximately 15 persons have expressed their intentions to join. Geographical boundaries of the Section include San Diego and Imperial counties.

300 Register for Course

Registration of about 300 for the Short Course on Corrosion held February 2-6 at Berkeley, by the University of California with the coperation of the National Association of Corrosion Engineers.

New York U. Board

Charles R. Cox, president of Kennecott Copper Corp. has been named chairman of a newly created board of development for New York University. The board will help determine and implement policies in connection with the university's ten-year $102,000,000 program for building and endowments.

Army Service Tests New Mobile Water Purification Unit

The Army Corps of Engineers Research and Development Laboratories, Fort Belvoir, Va. has tested on a 10-week tour of seven sites from Bear Lake, Utah to Fort Knox, Ky. a new mobile, truck mounted water purification unit. The electrically powered device will treat, clarify, filter and distribute 3000 gallons of water an hour in temperatures as low as 40 degrees below zero.

Polluted water is clarified and ready for drinking in 20 minutes after being taken up. The unit can be operated by one man and three men can put it into operation in less than 90 minutes.

It is estimated the output of this plant would be sufficient for the minimum drinking needs of nearly 50,000 persons. While developed principally for military purposes the unit has many applications for civilian uses.

It was developed by R. P. Schmitt, Chief of the Water Supply Section and Harry N. Lowe, Jr., Chief of the Sanitary Branch of the Fort Belvoir Laboratories and Charles H. Spaulding, Urbana, Ill., consultant.

Indian Institute Moved

The office of the Indian Institute of Metals has been moved to 31 Chowringhee Road, Calcutta 16. The Sixth Annual Meeting of the institute was held February 26-28 at Bangalore.

NOW!

Vitrabestos

NICOLET GLASS REINFORCED ASBESTOS PIPE LINE FELT

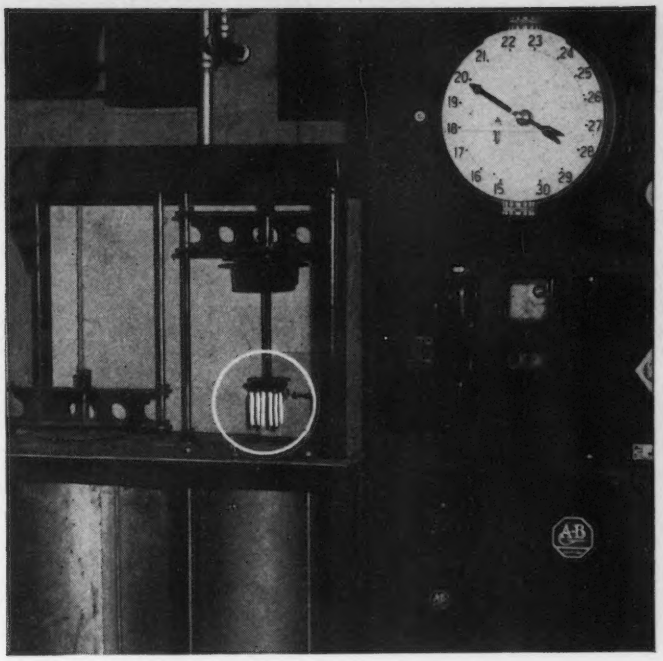
This Nicolet development is now available after months of intensive research and field testing. If you would like a sample of VITRABESTOS for close examination, write direct to Middle West Coating and Supply.

The Felt With a Future

MANUFACTURED BY:
NICOLET INDUSTRIES, INC.
70 Pine Street New York 5, N. Y.

DISTRIBUTED BY:
MIDDLE WEST COATING & SUPPLY
207-A Daniel Bldg. Tulsa, Okla. Ph. 2-5215
P. O. Box 153 or 2-5216

SCALING RESISTANCE EVALUATED AT HIGH TEMPERATURES



High-Temperature Corrosion Often Is the Main Factor in Metal Failure

Learning why metals fail at high temperatures – determining the actual cause of damage and suggesting as a remedy a more suitable material—these are the jobs of INCO High-Temperature Engineers, who are getting information on such problems for the use of industry.

INCO laboratories in Bayonne, N. J., and Huntington, West Va., have useful data on the properties of metals at elevated temperatures. This information comes from tests made to determine the creep strength, stress-rupture, and other properties of materials at temperatures in some cases up to 2100°F.

Industrial experiences at high temperatures indicate that it is unwise to predict high-temperature performance on the basis of room-temperature properties or short-time high-temperature tests. Other methods have been developed that provide more accurate measures for judging materials.

The machine pictured above was especially designed by INCO Engineers for determining the effect of cyclic heating and cooling on sheet metals while exposed to oxidizing conditions. INCO High-Temperature research likewise covers damage by other corrosive atmospheres. Through work with this and other types of equipment INCO Engineers study the reasons for failure of alloys at high temperatures.

Due to the volume changes accompanying its formation, an oxide film formed at high temperatures on the surface of a metal or alloy is usually under compressive stress. Contraction stresses developed when the underlying metal is cooled further aggravate this situation – and with many alloys may cause rupturing of the normally protective oxide.

Among the factors which influence the resistance to oxidation, the physical characteristics of the formed scale are of importance. The sketches show how these characteristics may cause the breakdown of the scale and thus increase the rate of oxidation.

Blistering may occur in oxide layers having good elasticity but poor adherence to the metal surface.

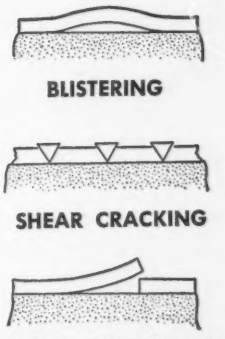
Shear cracking on the other hand will be found in oxides that are adherent but relatively brittle.

Flaking or spalling results when the oxide is both brittle and non-adherent.

As the scale peels away from the metal, it exposes a fresh area to further attack. A point of importance is that the loss of the oxide causes a progressive loss in metal section—useful load-carrying metal.

In high-temperature applications employing sheet or strip, the necessity of obtaining maximum resistance to this form of destruction by selection of a suitable heat-resisting alloy is of greatest importance.

Oxide Scale Breakdown by:



If high-temperature alloy performance is a problem to you, whether in present activities or in new projects, INCO High-Temperature Engineers will do their best to be of help to you. Let them send you the *High-Temperature Work Sheet*... it is a big aid in explaining your situation fully. Then see if INCO Engineers cannot help solve your difficulty.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street, New York 5, N. Y.

EMBLEM OF SERVICE INCO TRADE MARK

Belgian Center Begins Publication of Magazine Devoted to Corrosion

"Corrosion and Protection of Materials," a quarterly magazine published by the Royal Belgian Society for Engineers and Industries, is devoted to practical and theoretical information on corrosion. Active agency responsible for issuing the publication is Centre Belge D'Etude de la Corrosion ASBL, 21 Rue des Drapiers, Bruxelles of which Marcel Pourbaix, an NACE member and contributor of technical material to CORROSION is director.

Indices of the first three issues show that two articles previously appearing in CORROSION have been reprinted, "Corrosion of Railroad Hopper Car Body Sheets," by B. J. Kelly, from CORROSION, June, 1951 and "Corrosion Problems in the Modern By-Product Coke Plant," by C. F. Pogacor and E. A. Tice, from CORROSION, March, 1951. Other articles included one by F. L. LaQue, formerly president of NACE titled "The National Association of Corrosion Engineers," and other articles of practical and theoretical nature.

A publication titled "Complete View of the Electro-Chemical Behavior of Metals. Part 1," by Marcel Pourbaix, reprinted from L'Ossature Metallique, Jan.-Feb., 1953, also has been sent to NACE for inspection.

All publications are in French.

Welding Exposition Is Scheduled for Houston Four Days, June 16-19

The American Welding Society, 12 East 41st St., New York 17, N. Y. is sponsoring a 4-day, all-welding exposition at the Shamrock Hotel, Houston, June 16-19 in connection with the society's Spring Technical Meeting.

•

The 1953 annual meeting of South Central Region NACE will be held at Tulsa October 7-9 at the Mayo Hotel.

•

The Tenth Annual NACE Conference and Exhibition will be held at Kansas City in March, 1954.

BOOK REVIEWS

The Making, Shaping and Treating of Steel. By J. M. Camp and C. B. Francis. 6 x 9, cloth, 1584 pages. Sixth edition, June, 1951. The United States Steel Company, Pittsburgh, Pa. Availability not indicated.

An encyclopedic work on the making and fabrication of steel, the sixth revision of an edition published first in 1919. This volume covers in exhaustive fashion the historical and mechanical and economic aspects of steel production, including the necessary ancillary information on equipment and facilities and by-products of the various operations involved.

A 147-page topical index includes 211 references to various aspects of corrosion beginning with "Corrosion, Alloying elements for retarding" and continuing through "Corrosion-resistant steels, for seamless tubes." These items include effects of environments, effects of alloying elements, abrasion, types of corrosion, theory, inhibitors, corrosion-resistant finishes, greases, coatings, metal powders, vitreous coatings, foundry practice with corrosion-resistant steel castings, and several kinds of testing.

As a source of general information on steel making and related subjects it is likely this book is among the more comprehensive treatises available.

More Than 4000 Persons Are Members Of NACE on Jan. 1

More than 4000 persons were listed as members of the National Association of Corrosion Engineers as of January 1, 1953. During the week of February 8 the association issued membership number 5000 indicating that only 1576 persons have left the association by death, transfer, resignation or otherwise in its nine years. The apparent numerical discrepancy is explained by the fact corporate memberships are transferable, whereas active and junior memberships are not.

•

NACE now has more than 4000 members.

NACE MEMBERS CHANGING STATUS

Notification to Central Office NACE of changes of membership status, including changes of address should be made *personally* by the member.

NACE is reluuctant to make changes in membership records except *when asked to do so by members themselves.*

Please note also:

1. **Active and junior memberships are *non-transferable*, because applications are signed personally by members, therefore**
2. **All persons wishing to become members of NACE must submit and *sign personally* an application containing a concise statement of qualifications and including the names of two NACE members in good standing as references.**

Factors in Automobile Corrosion Discussed At SAE Meeting

Most corrosion of automobile bodies proceeds from the inner surfaces partly because of the inferior finishes applied to those surfaces, according to F. L. LaQue, head of the Corrosion Engineering Section of the Research and Development Division of The International Nickel Co., Inc., New York. Mr. LaQue, speaking to the National Passenger Car, Body and Materials Meeting of the Society of Automotive Engineers March 3 at Detroit, also said the corrosion damage to automobile bodies is determined by the nature and amount of corrosive pollutents in the air in which the cars operate, plus the superimposed effects of materials thrown up from streets or roads.

Other factors listed by Mr. LaQue were: humidity, amount of rainfall, dust particles, ashes and soot, salt from seacoast atmosphere and street deicing applications, products of combustion in industrial atmospheres, nitric acid generated by synthesis from nitrogen and oxygen by the action of lightning and others.

Steels used for automobile body fabrication are selected for low cost and fabrication qualities. Resistance to corrosion can be raised by addition of phosphorus, chromium and nickel or by a phosphate pretreatment before painting.

Plummer Is Elected By Welding Society

The American Welding Society has elected Fred L. Plummer, director of engineering, Hammond Iron Works, Warren, Penna., as its president for 1952-53. Mr. Plummer will direct activities of the Society for 1952-53 after taking office during the annual meeting of the Society last October.

Mr. Plummer holds degrees from Ohio University and Case School of Applied Science. He is a registered engineer in the states of Ohio, New Jersey and New York, is a member of the Sigma Xi, Tau Beta Pi and Phi Betta Kappa honorary societies. In 1928 while on leave from Case, he was in charge of the structural analysis and design of the world's largest airship dock for Goodyear Zeppelin Corp., at Akron, Ohio. Following the outbreak of the Korean War, he headed a group of engineers and production managers sent to assist Japanese manufacturers and fabricators of steel in setting up standard procedures and facilities for producing necessary special steels and fabricating Bailey bridge parts which would be interchangeable with those produced in the United States and Great Britain.

New Abstract Source Is Added by NACE

Abstracts of articles published in the German periodical Stahl und Eisen, a publication of Verlag Stahleisen M.B.H., Dusseldorf will appear in CORROSION and in the NACE Abstract Card Service. The code identifying the source which will appear at the end of abstracts from this publication will be the letters "SE."

AMERICAN CHEMICAL PAINT COMPANY

AMBLER CHEMICALS ACP PROCESSES PENNA.

Technical Service Data Sheet

Subject: HOW *GRANODIZING* PROTECTS STEEL DRUM SURFACES FROM RUST AND IMPROVES PAINT ADHESION

NEW DEVELOPMENT IN CONTAINER INDUSTRY

United States Steel Products Division, United States Steel Company is now producing grease-free, scale-free, rust-inhibited steel drums. A chemically clean metal surface plus a "Granodine"* non-metallic zinc phosphate coating insures maximum finish durability and underpaint rust-resistance. *Trade Mark Reg. U.S. Pat. Off.

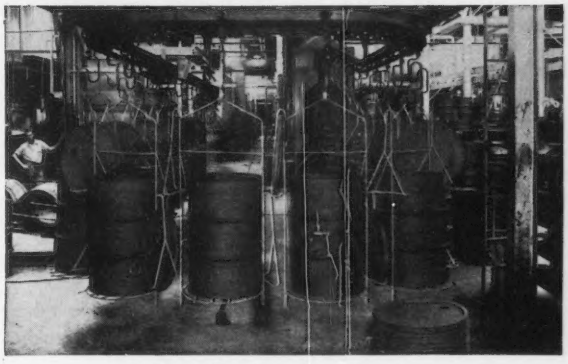
ORDINARY PAINTED DRUM after a year of exposure to weather is badly rusted. Rust was very apparent after only one week.

U. S. S. RUST-INHIBITED DRUM of similar type shows absolutely no rust after same year's test.

THE PROTECTIVE CHEMICAL TREATMENTS

The Granodizing process embodies the following steps:

1. Grease and dirt removal
2. Full scale removal, after welding the side seam
3. Zinc phosphate coating with "Granodine"
4. Acidulated rinsing in "Deoxylyte" solution



Port Arthur, Texas, Cleaning Line

U. S. S. drums about to enter the 400 foot cleaning and treating line. Powerful impingement sprays directed at the fabricated shell, head, and bottom, insure that the entire interior and exterior of the drum will receive full cleaning and rust-inhibiting treatment.

ADVANTAGES OF GRANODIZED STEEL DRUMS

These new phosphate-coated steel drums exhibit many advantages for companies using these containers.

They are chemically clean, "water-break free" inside, free of contaminating residues such as grease, oil, drawing and stamping compounds. When the familiar handkerchief test is applied to United States Steel Products' containers processed by their new finishing technique, no contamination of any kind is left on the cloth.

They are free of mill-scale. United States Steel Products is the first steel drum manufacturer to remove harmful mill scale completely ahead of the zinc phosphate coating stage.

They are rust-inhibited with a zinc phosphate-coating. These new steel drums have the added advantage of a non-metallic, paint-bonding "Granodine" zinc phosphate coating. This has been standard practice for many years in the automotive and appliance industries for long-lasting paint protection and metal preservation.

CHEMICALS ACP PROCESSES

WRITE FOR INFORMATION ON "GRANODINE" AND ON YOUR OWN METAL PROTECTION PROBLEMS

CHEMICALS ACP PROCESSES

NEW PRODUCTS —Materials—Service—Literature

Better Analysis, a periodical issued by Baird Associates, Inc., 33 University Road, Cambridge, Mass., and available on request to persons interested in its subject matter, contains in its issue No. 1 of 1953 articles on infrared spectrometry, preparation and use of punch cards containing printed spectra, and other information in this field.

•

New Frontiers, a biannual publication of The Garrett Corp., 9851 Sapulveda Blvd., Los Angeles 45, Cal. contains information interesting to persons in the aircraft and high temperature metallurgical fields. No. 1 of Vol. 1 includes an article on auxiliary power for the jet transport which covers the gas turbines developed for this purpose.

•

Polyethylene 1-inch and 2-inch bore valves made by American Agile Corp., P. O. Box 168, Bedford, Ohio are recommended for use in handling hydrofluoric, sulfuric, nitric and hydrochloric acids at temperatures up to 160 degrees F. They are furnished with standard drilled flanges. A 2-inch valve weighs less than 6 pounds.

•

Henry Valves Company, 3215 North Ave., Melrose Park, Ill., manufacturers of valves for handling anhydrous ammonia and steel fittings for soil fertilization and industrial equipment will send on request its catalog No. 801 describing the equipment.

•

Mineralite, a portable source of black light for inspecting fluorescent materials is manufactured by Ultra-Violet Products, Inc., 145 Pasadena Ave., South Pasadena, Cal.

•

Porcelain Valvrator diaphragm air-motor valves manufactured by Fischer & Porter Co., Hatboro, Pa. for corrosive service have a new safety feature. The porcelain is encased in layers of glass cloth impregnated with resins to form a coating with physical properties approaching those of steel. While the armoring will not prevent leakage, danger to personnel and plant is minimized. The new valves are described in Catalog 70, Supplement 5 available from the company's offices 771 Jacksonville Road.

•

Trioxane, a crystalline form of formaldehyde has been made available in continuing commercial quantities by Celanese Chemicals, 180 Madison Ave., New York 16, N. Y. It is useful in the formation of organic intermediates and resins, is an excellent solvent and reaction medium and may be used as a stabilizer for trichloroethylene and zein solutions.

•

Alloy Digest, a monthly publication of data sheets by Engineering Alloys Digest, Inc., Upper Monclair, N. J. is available on a subscription basis. The data sheets include material of practical engineering value about metals and alloys, including origin, analysis and other information in tabular and graphic form.

•

National Preformed Spectroscopic electrodes manufactured by the National Carbon Company, a Division of Union Carbide and Carbon Corp., 30 East 42nd St., New York 17, N. Y. are now subjected to an exclusive purification process after fabrication before being placed in a newly-designed package intended to prevent contamination before use. Catalog Section A-4004 describes the electrodes.

•

Metalweld's MW Protective Coatings Division has installed in its new Scott's Lane Plant a large rubber vulcanizing machine for joining hard and soft rubber sheets to steel accommodating tank lining jobs up to 12 feet in diameter by 26 feet long.

•

Insul-Mastic Corp. of America has licensed the following contractors: Sprinkman Sons Corp., 837 South Washington St., Peoria, Ill.; Fiberglas Contracting & Supply Co., of Ohio Valley, 4610 Smith Road, Cincinnati 12, Ohio; California Coatings, Inc., 4923 Folsom Blvd., Sacramento, Cal. and North Bros., P. O. Box 986, Birmingham, Ala.

•

Bakelite fluorothene resins are expected to be made this year in a new plant under construction at South Charleston, W. Va. by Bakelite Co., a Division of Union Carbide & Carbon Corp. The name is that given by Bakelite to its polychlorotrifluoroethylene compounds. Three grades are to be made at the new plant.

•

Roylac aluminum, a product of Royston Laboratories, Inc. an industrial aluminum coating which can be applied with a spray gun even on wire fencing with virtually no overspray, is described in a new bulletin available from the company at its Blawnox, Pa. offices. The material in motion dries within four feet into a cottony, non-adhering powder. It is based on a clear, styrene type vehicle and contains two pounds of aluminum paste per gallon.

•

Ampcolite, made of high impact styrene, is the name given to piping made by Atlas Mineral Products Company in ½-inch to 6-inch OD sizes. It is available in 10 and 20-foot lengths.

•

Isotope Products, Inc., a new company, has been formed by Petrol Structors, Inc. of New York, Houston and Tulsa and Isotope Products, Ltd., of Oakville, Ontario to exploit the industrial use of isotopes produced by the Chalk River atomic pile. Isotope Products, Ltd., in its February 20 newsletter says the new firm will expand the use of gamma ray radiography to check welds, locating and measuring corrosion, inspect castings and other similar applications. Isotope iridium 192 in particular, the newsletter says, makes feasible rapid inspection with portable equipment of welds on oil pipe lines, storage tanks, Horton spheres and refinery equipment. The new firm will devote itself first to the petroleum industry, with an establishment at Houston and O. P. Herzig and A. L. Mott as representatives. The Foxboro Company has distribution rights for Isotope Products instruments in the United States. The Canadian NRX pile at Chalk River, in which heavy water is used as a moderator and water used for cooling, has been shut down for an indefinite period for reasons not specifically given but which may include damage from corrosion and mechanical attack. Construction of a new pile of like characteristics with the designation

(Continued on Page 18)

Stop Corrosion . . .

WITH **HARPER**

EVERLASTING FASTENINGS

If you use fastenings of brass, bronze, copper, Monel, aluminum or any stainless steel, you can get what you want from Harper. Over 7,000 items stocked—all backed by Harper's advanced metallurgists and skilled engineers. See your Harper Distributor.

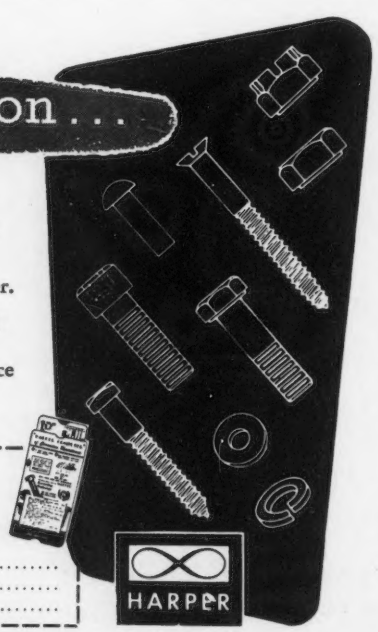
The handy Computer of Corrosion Resistance of metals to 143 different corrosive agents is yours on request.

FREE **MAIL COUPON TODAY!**

The H. M. Harper Company
8221 Lehigh Avenue
Morton Grove, Illinois

Please send me
☐ Harper Computer of Corrosion Resistance
☐ Harper Catalog

Name.....
Address.....
City.....*State*.....



SOMASTIC★

..."ONLY 23 years old, but what a record!"

23 YEARS is a long time on the job, preventing corrosion damage to underground pipe. SOMASTIC Pipe Coating has furnished complete protection at severely corrosive locations since its first year—1930.

In fact, our knowledge of its useful life is limited only by the total time it has been in existence.

2 ECONOMICAL METHODS OF APPLICATION:

... by Central Plant

... by portable Railhead Plant

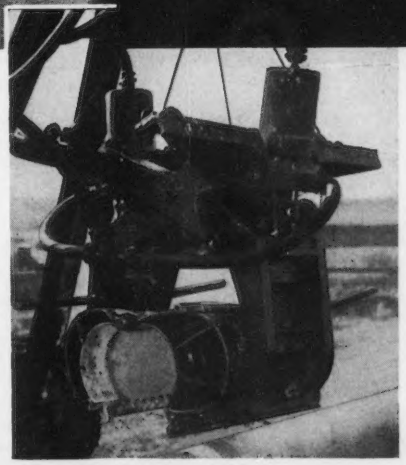
SOMASTIC IS The Best PIPE COATING

SOMASTIC PIPE COATING

*Reg. U. S. Patent Office

The sure protection of impervious asphalt-mastic—won't distort under soil stresses; resists shock; prevents electrolysis. Ductile; inert; firmly bonded to pipe.

RAILHEAD PLANT. Choice between railhead and central plant depends on the economics of a specific job.



HYDRAULIC FORM. Field joints make SOMASTIC protection continuous along the entire coated line.

Inquiries invited

H. C. PRICE CO.

BARTLESVILLE, OKLAHOMA
PHILADELPHIA, PA.
NEW ORLEANS, LA.

In the 37 States East of the Rocky Mountains

BECHTEL CORPORATION

SAN FRANCISCO and
WILMINGTON, CALIFORNIA

In the 11 Western States and in Foreign Countries

NEW PRODUCTS

(Continued From Page 16)

NRU is expected to be completed in 1954. This pile, like NRX, uses heavy water and water cooling which permits neutron flow up to ten times the intensity of that in piles using other moderators and coolants. Alternative atomic energy sources in the United States are providing a supply of isotopes to the Canadian firm.

•

Rust-Tox, a product of The Skybrite Co., 3125 Perkins Ave., Cleveland 14, Ohio is a material which manufacturers claim penetrates rust and bonds it to the clean metal beneath. It is necessary only to remove loose rust, the company says before using the material. No primer is needed and one coat often is sufficient. It dries with a glossy, elastic film. A 4-page brochure explaining the uses of this and other heat resisting paints is available on request.

•

Kelite Spray White, an industrial cleaner applied by a handsized pressure spray gun is said by the manufacturers, Kelite Products, Inc., 1250 North Main St., Los Angeles 12, to remove grease, oil, wax, gums, dirt, ink, cutting soap, light carbon and other materials without damaging metals, plastics rubber, porcelain, concrete or wood. No heat odor, fumes or toxic effects are created, the company says.

•

Hysol 3000 series plastisols, dispersions of high molecular weight polyvinyl chloride resins are available in several forms from manufacturers Houghton Laboratories, Inc., 322 Bush St., Olean, N. Y. A bulletin describing the material in detail is available on request.

•

Vinysite FS-3, a yellow vinyl primer designed for application by roller, on ferrous metals and when baked provides a good bond for finish coats manufactured by Thompson & Co., 1085 Allegheny Ave., Oakmont, Pa. The company also makes other types of Vinysite for dip, spray and brush coating of other metals and non-metals.

•

Anarust, a liquid rust inhibitor of organic composition containing no chromates has been originated by American Wheelabrator & Equipment Corp., 1170 South Byrkit St., Mishawaka, Ind. The inhibitor is designed for use with wet blasting materials to retard rust formation on cast iron or steel cleaned after wet blasting. Soluble in hard or soft water at 20 degrees C, it produces a colorless solution, odorless, non-irritating to the skin and not subject to bacterial decomposition. It is non-foaming and keeps water staining of ferrous parts to a minimum.

•

Stainless Steel chemical mixing tanks for laboratory and industrial use are now being made with an inverted air-seal transparent resin cover by Reco Sales Co., 70 East 45th St., New York City. The cover floats on top of the tank contents, eliminates evaporation, contamination and oxidation and permits vortex-free mixing.

•

Paint Systems for Hydraulic Structures, Technical Letter No. 7 of the Lead Industries Association, 420 Lexington Ave., New York 17, N. Y. dated August, 1952 gives seven formulas of paint systems for use for hydraulic structures. The formulas were designed especially for application to surfaces exposed to moist and chemically contaminated atmospheric environments as well as surfaces immersed intermittently or continuously in fresh water. Copies of the letter are available on request.

•

Lead, a periodical published by Lead Industries Association, 420 Lexington Ave., New York 17, N. Y. in its Vol. 19, No. 1 issue describes the "Harvey System" of coating developed by Clarence C. Harvey, corrosion engineer for the Ethyl Corporation's Baton Rouge, La. plant. The system, designed to protect chemical process equipment from regular and intermittent exposure to chemical fumes, has been developed by tests over five years by Mr. Harvey. An article on this same subject by Mr. Harvey was published in CORROSION, Vol. 6, No. 10, 323-326 (1950) Oct.

•

Nocor, a corrosion inhibitor with high average molecular weight, which the manufacturer, Cardinal Chemical, Inc. of Odessa, Texas, says adsorbs to steel surfaces in such a manner the non-polar oil-soluble portion of the molecule extends normally from the steel surface in a tight film through which ions cannot diffuse, is synthesized from low cost raw materials. It does not change the pH of brines and is completely insoluble in water. Further information on the material is available on request from A. A. Townsend, Odessa.

•

Southern Pipe and Casing Co., Azusa, Cal., has issued a 42-page catalog describing pipe, fittings, field joints, protective coatings and types of pipe from 4 to 36 inches in diameter. Free copies are available. Techniques used in applying internal and external coatings, including wire-reinforced concrete exterior coatings are described.

•

Data on wrought iron pipe is given in English and Spanish in a bulletin available from A. M. Byers Co., 30 Rockefeller Plaza, New York City.

•

Titanium sponge producing facilities of E. I. Du Pont De Nemours & Co., Inc. at Newport, Del. are being expanded and are expected to begin operating at Edge More, Del. soon. An additional 13,500 tons of titanium in five years will be made possible.

•

Baromix, a powdered asphalt paint available in aluminum and three colors is mixed as needed with kerosene for application with brush or spray gun. It will not flow on vertical surfaces up to 325 degrees F. Manufacturer is Berry Asphalt Company, Magnolia, Ark.

•

Porcelain Tank Linings made by How E. Baker Company, 1499 East Fourth St., Los Angeles 33, Cal. are said by the manufacturer to be tasteless, inert and crack free, with good resistance to chlorides, dissolved oxygen and electrolytic action, besides being resistant to heat.

•

Freon, because of its tendency to escape from small apertures and its tendency to modify the color of a flame in which it burns, is now being widely used to locate leaks. An electronic leak detector pulled along suspended telephone cable into which Freon has been pumped will inspect cable at 120 feet a minute.

•

An Exhaust Head for stacks which cleans vapor of nuisance particles and which has no moving parts has been developed by the V. D. Anderson Co., 1935 West 96th St., Cleveland 2, Ohio. The vapor entering the purifier is engaged by a stationary centrifugal element which imparts rapid rotational movement to the vapor. Entrained particles are thrown outward to the walls of the purifier and drained. Efficiency of 99 percent is claimed.

•

Curtains charged with 60,000 volts of electricity ionize particles of dust from roaster and converter gases of the Copper Cliff, Ontario smelter of The International Nickel Co., Inc. so that grounded 22-foot rods acting as collecting electrodes will attract the charged particles. Once during each shift the current is turned off and rods are tapped by pneumatic hammers to dislodge the dust, which falls into bins. The dust is then blown into the reverberatory furnaces. A close watch is kept on the temperature of the gases entering the treater section so the dew point of included vapor will not be reached. This vapor condenses into a corrosive acid solution which corrodes the equipment.

•

The Project Engineer, January 1953, a publication of the Thermix Corp., Greenwich, Conn. contains an article "Efficiency Prediction" which outlines a method of computing the overall collection efficiency of dust collectors.

•

The Pall Filtration Companies, an amalgamation of Micro Metallic Corp., Aircraft Porous Media, Inc. and Porous Plastic Filter Co. under the leadership of David B. Pall is announced. The company is at Glen Cove, N. Y. The firm will make porous stainless steel and other metal filters, and Teflon and Kel-F sheet and fabricated forms.

•

Formbrite is the name of a metal developed by The American Brass Company, Waterbury 20, Conn. described in Publication B-39. Its fine grain makes it suitable for press room products and economy in subsequent finishing operations.

•

Karbate impervious graphite heat exchangers are described in a new Catalog Section S-6740 available from National Carbon Company, a Division of Union Carbide & Carbon Corp., 30 East 42nd St., New York 17, N. Y.

•

G-E Ultrasonic Generators are used by Miniature Precision Bearings, Inc. to clean ball-bearing assemblies. Fifty parts can be cleaned simultaneously in less than a minute, speeding the cleaning process ten times.

•

Six Shades of finish almost impossible to distinguish from gold can be applied to aluminum by a process called D'orium by Miracle Finishes, Inc., 10 Water St., Brooklyn 1, N. Y. The gold and other colors which may be produced have a high luster, are non-corrosive and will not separate from the base because they are integral, manufactur-

(Continued on Page 20)

control corrosion
in cooling water systems with

Calgon* THRESHOLD TREATMENT

Corrosion control in water systems is effected with Calgon Threshold Treatment†. A protective film forms on metallic surfaces which ends corrosion difficulties in pipes, tubes, and on heat transfer surfaces.

The Calgon film protects all types of industrial cooling water systems. Write a letter telling us about your problems, and our engineers will be glad to show you what Calgon can do. And send for your free copy of our booklet, "Calgon Controls Corrosion."

*T.M. Reg. U.S. Pat. Off.

†Calgon Threshold Treatment for controlling corrosion licensed under U.S. Patent 2,337,856.

HAGAN HALL BUROMIN CALGON

calgon, inc.

A SUBSIDIARY OF HAGAN CORPORATION
HAGAN BUILDING
PITTSBURGH 30, PA.

CLEANING, COATING, WRAPPING & RECONDITIONING

★

HOT DOPE

Straight from the Kettle on PIPE PROTECTION

★

By Boyd Mayes

• An oldtimer in pipelining dropped in the office the other day to pay his sympathies . . . said he'd just heard we were broke; that we may be folding up the business any day now. His story wouldn't have been nearly as funny without tying it in with one a customer of ours had heard the day before. The story he'd heard was that we'd made so much money that we didn't have to work . . . that we weren't interested in our business any more, and that we wouldn't walk around the corner to bid on a job. Now, to our way of figuring, it's not only very embarrassing to wake up one morning rich and the next morning broke, but it's darned confusing to the trade. We've been too busy cleaning, coating and wrapping pipe to stop and count our money the past few weeks but we do know, for sure, that we've got more than a million dollars invested in one of the most modern plants in the business, permanently fastened down on a 56-acre yard that's pretty well stacked with customers' pipe, and operated by around 80 skilled craftsmen who get their paychecks on the dot. We've got enough to turn out any size pipe coating or reconditioning job, and we think that's about all the pipe line industry is terribly concerned about!

MAYES BROS.

1150 McCarty HOUSTON, TEXAS ORchard 7566

NEW PRODUCTS

(Continued From Page 18)

ers say. Coloral, S. A. of Switzerland is the licensor.

•

Asbestoprene, a combination of asbestos and neoprene, is made by Victor Manufacturing and Gasket Co., Chicago. The gasket material, superior to other materials used in many respects, does not corrode light metals, is resistant to oils, water and antifreeze solutions and has high heat resistance.

•

Bulletin TDC —146 issued by The Tubular Products Division, The Babcock and Wilcox Company, Beaver Falls, Pa. discusses B & W Croloy 5 (4-6 percent chromium, ½ percent molybdenum) tubes for refinery and process industry applications. It is said to be particularly resistant to corrosion from hot oil, hydrogen sulfide, elementary sulfur and organic sulfur compounds encountered in petroleum operations.

•

RTS 200, a non-corrosive rosin core solder has been developed by Federated Metals Div., American Smelting & Ref. Co., New York. Oxide films and corrosion products on the parts being soldered need not slow down operations because the solder penetrates retarding agents four times faster than ordinary solders, the company claims. No harmful corrosive residue when tested under high humidity conditions of MIL-S-6872 was noted. It is non-toxic.

•

Tri-Clover Machine Co., Kenosha, Wis. had developed a conversion tool which will convert bevel seat sanitary fittings to close-fitting leak-tight gasket seat joints. The converted fittings take special Hycar gaskets.

PERSONALS

Wakefield Baker has been elected a member of the Pabco Products, Inc. board of directors.

•

Carl E. Schmitz has been appointed vice-president in charge of sales for Crane Packing Company, Chicago. He formerly was vice president and director of engineering. Five divisions sales managers have been designated as follows: **E. H. Stubenrauch,** mechanical packings; **Stephen Hawxhurst,** Teflon products; **Harry I. Sole,** lapmaster; **V. E. Vorhees,** mechanical seals and **Stillman Segar,** plastic lead seal.

•

H. L. Rhodes has been named manager of the Chemicals-Pigments-Metals Division plant at Oakland, Cal. of The Glidden Company.

•

C. B. Post, chief metallurgist for The Carpenter Steel Company, Reading, Pa. has been awarded the Bradley Stoughton plaque, presented annually to the Lehigh Valley metallurgist who has accomplished the most outstanding and generally useful metallurgical work. The award, made by the Lehigh Valley Section of the American Society for Metals, is the third going to Carpenter metallurgical personnel.

NACE BOOKS and PAMPHLETS

on

CATHODIC PROTECTION

•

CATHODIC PROTECTION
A Symposium
(The Electrochemical Society and the National Association of Corrosion Engineers)

Cloth, 8½ x 11, 203 pages. 23 Papers, comprehensive, authoritative information on cathodic protection from both theoretical and practical standpoints. Illustrated. Many references.
Postpaid to members of ECS and NACE, Per Copy.....$6.00
(Others, $8.00)

•

Report of the Correlating Committee On Cathodic Protection

Bulletins I, II, III and IV. Paper, 6 x 9, 33 pages. Bulletins outlining the recommendations by 11 associations and organizations operating and interested in protecting metals underground or submerged from corrosion. Data covered includes recommendations on design, notification procedures suggested when cathodic protection systems are being installed, customary technical practices and information on the operation of joint systems. Valuable appendices include selected bibliography on cathodic protection.

Copies	Each
1 to 10	50¢
11 to 100	35¢
Over 100	25¢

Postpaid to a single address.

•

Control of PIPE LINE CORROSION
By O. C. Mudd, Chief Corrosion Engineer, Shell Pipe Line Corp., Houston, Texas.

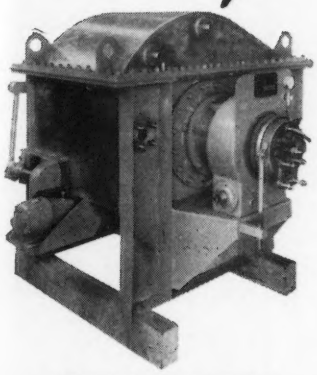
Paper, 6 x 9, 61 pages. Thousands of copies of this booklet have been sold. It covers in easy-to-read style the theories of corrosion of underground pipe lines, tells methods of investigation, instruments required, explains electrical protection, installation of anodes and ground beds and covers the economics. Illustrated.

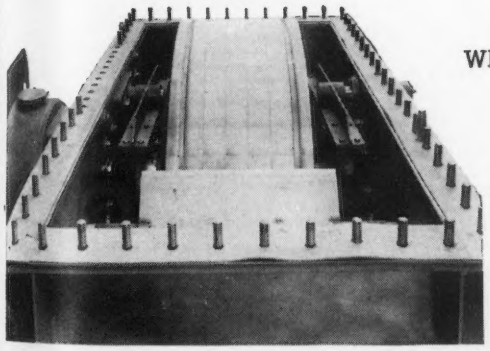
Per Copy, postpaid.....$1.25
(5 or more copies to one address, per copy $1)

Send Orders to
A. B. Campbell, Executive Secretary
NATIONAL ASSOCIATION of CORROSION ENGINEERS
No. 1 MAIN STREET
1061 M & M Bldg. Houston 2, Texas

A COMBINATION OF CORROSION PROBLEMS —all solved with *Carpenter* materials

sulphuric acid, nitric acid and potassium permanganate safely handled by Stainless #20





The materials handled by this continuous vacuum filter are not only corrosive but toxic. The principal corrodent in the filtrate is sulphuric acid (PHl). The solutions used for periodic cleaning of the filter are nitric acid and potassium permanganate.

To withstand this combined attack, all parts of the filter that come in contact with slurry, cake or filtrate are made from Carpenter Stainless #20—sheet, pipe, nipples, electrodes, rounds, etc. The hood to contain the gases is made from Carpenter stainless sheet, type 316.

Wherever corrosion is a problem, it will pay you to get in touch with your nearby Carpenter Distributor. He can put at your disposal our 25 years of experience in providing materials to withstand corrosion and the necessary "know-how" to fabricate them easily. The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y. "CARSTEELCO"

New 16-Page Book of Technical Data

For complete information on No. 20 and the jobs it can do, write us a note on your company letterhead and ask for the new Carpenter Stainless No. 20 book.

Carpenter

STAINLESS TUBING & PIPE

- guaranteed on every shipment

Write for Rates. 1061 M & M Bldg. Houston 2, Texas

CORROSION DIRECTORY

Over 5000 Paid Readers Monthly

Cathodic Protection

ALL-CO
CATHODIC PROTECTION
Design • Installation • Surveys
Equipment • Supplies
ALLEN CATHODIC PROTECTION CO.
P. O. Box 386 Phone EDison 2081
HARVEY, LOUISIANA

Cathodic Protection Service
Engineering - Installation - Surveys
Material – Supplies
Everything in the Cathodic Protection Field from an Insulating Washer to a Turnkey Contract Installation
4601 Stanford – HOUSTON – Phone JA 5171
NEW ORLEANS 1639 Robert St. Phone CH-8310
TULSA 310 Thompson Bldg. Phone 2-9857

CORROSION RECTIFYING CO.
1506 ZORA ST. VA 7522 HOUSTON
CATHODIC PROTECTION
SURVEYS – DESIGN – INSTALLATION
• Pipe Lines • Offshore Platforms
• Refinery & Gasoline Plant Lines
• Municipal Systems • Barges

CORROSION SERVICE LIMITED
Offers in CANADA
A Complete Service in Corrosion Engineering, Design and Installation of Cathodic Protection Systems.
Resistivity and Electrolysis Surveys.
Selection and Application of Protective Coatings.
Rectifiers — Anodes — Materials
77 York St., Toronto, Canada

CATHODIC PROTECTION
Surveys Engineering
Installation Maintenance
Electro Rust-Proofing Corp. (N. J.)
BELLEVILLE 9, NEW JERSEY
Atlanta – Chicago – Dallas – Monrovia

• *Complete*
CATHODIC PROTECTION
Systems . . . supplies . . . service for special applications; water tanks and pipe lines.
HARCO CORPORATION
16901 Broadway Cleveland, Ohio

Cathodic Protective Systems Designed and Installed
Coating and Laying Specifications; Corrosion Surveys; Consultation On All Types of External Pipe Line Corrosion.
Huddleston Engineering Co.
Bartlesville Oklahoma

Cathodic Protection

Pipeline Maintenance
Again in 1952, we lead all contractors in Magnesium Anodes Installed
LET US SHOW YOU WHY
CATHODIC PROTECTION INSTALLATION ENGINEERING – SURVEYS
(Complete job or installation only)
PIPELINE *Maintenance* CORPORATION
3-8126 TULSA, OKLAHOMA BOX 1424

Dependable Selenium Rectifiers for Cathodic Protection
are manufactured by
Richardson-Allen Corporation
a manufacturing affiliate of
WESLEY BLOCK AND COMPANY
39-15 MAIN STREET, FLUSHING, NEW YORK
IN CANADA: Richardson-Allen of Canada, Ltd., 370 Victoria St., Toronto, Ontario

RIO ENGINEERING CO.
Cathodic Protection Systems
Surveys Installation Design
1434 West Alabama
HOUSTON 6, TEXAS
KE 9792

CATHODIC PROTECTION
Distributors and Contractors
• T. D. Williamson Casing Insulation
• Good-All Rectifiers • Dow Magnesium Anodes • National Graphite Anodes • Instruments and Insulation • Contract Anode Installations.
STUART STEEL PROTECTION CORP.
Kenilworth New Jersey

Coatings and Linings

CORROSION ENGINEERING
and application of chemical resistant linings and coatings
Exhaust Systems
Storage, Plating and Pickling Tanks
Tank Trailers
Pipe—Degreasers
Filter Presses
A & P FINISHING & MFG. CO.
17760 Clarann Avenue
MELVINDALE (Detroit) MICH.

CORROSION-PROOF LININGS CEMENTS BRICK
• TANKS, FLOORS, FUME DUCTS AND PROCESS EQUIPMENT
• COMPLETE LINE OF PROTECTIVE COATINGS..
Over a Quarter Century of Experience
CEILCOTE CORROSION-PROOF MATERIALS • CONSTRUCTION • SUPERVISION
The CEILCOTE Co. 4832 RIDGE RD. CLEVELAND 9, OHIO

Coatings and Linings

HARTMAN – HANKS – WALSH PAINTING COMPANY
5078 Easton Ave. St. Louis 13, Mo.
Cable APCO—Phone FOrest 6222
SPECIAL COATINGS APPLICATORS
Sandblasting Painting
• Perma-Skin Anti-Corrosion Vinyl Coatings
• Spring-Kote Corrosion Resistant Mastics
• Dum-Dum Masonoc – A Complete Spray Painting Service

Engineering Service

DEUBER LABORATORIES
Bacterial Corrosion Fungus Resistance Tests
Soil Performance Tests of Coatings, Tapes, etc.
Industrial Research
114 East 32nd Street New York 16, N. Y.
Telephone: LExington 2-3244

CORROSION ENGINEERING
SURVEYS • DESIGNS • SPECIFICATIONS
Impartial Evaluation
THE HINCHMAN CORPORATION
Engineers
Francis Palms Bldg., Detroit 1, Mich.

A. V. SMITH ENGINEERING CO.
CONSULTING ENGINEERS ON CORROSION PROBLEMS
Coulter Bldg. Ardmore, Pa.
Midway 2-9999

Instruments

INSTRUMENTS
For the Corrosion Engineer
• Copper Sulfate Electrodes
• Resistivity Rod & Pipe Prod
• AC Bridges
• No Current Potentiometer with Current Ranges
J. L. COLLINS
ANGLETON, TEXAS

Pipe Coating and Wrapping

SERVING ALL PIPELINES
PIPELINE ASBESTOS FELT
Made by The Ruberoid Co.
COAL TAR ENAMEL COATINGS
Made by Pittsburgh Coke & Chem. Co.
FIELDJOINTERS
Made by American Coating Supply Co.
"Steve" Day
S. D. DAY COMPANY
1973 W. Gray Houston 19, Tex.
Phone JU-2431

Advertising in this Directory costs about $1.25 a thousand circulation in 46 states and 40 foreign countries

AWWA Convention To Be Held May 10-15 At Grand Rapids, Mich.

The American Water Works Association will hold its 73rd Annual Convention at Grand Rapids, Mich. May 10-15, 1953, according to an advance program.

On the program for Tuesday afternoon are papers and discussion on The New Standards for Cast Iron Pipe. Titles of the papers and their authors are: "Development of New Standards for Cast Iron Pipe," by Thomas H. Wiggin; "Resulting Changes in Production Methods," by Thompson Vann and H. W. Stuart; "A Consulting Engineer's Appraisal," by L. R. Howson; "Management's Appraisal," by W. R. LaDue; "Studies on the Mechanism of Corrosion," (scheduled for 3:30 p.m.) by James Lamb, III, and Rolf Eliassen; and Cast Iron Pipe Coatings as Related to Corrosion," (scheduled for 4:00 p.m.) by John R. Baylis.

On Monday, 10:15 a.m. a paper on the "Stationary Storage of Liquid Chlorine," by A. S. Woodward and L. L. Hedgepeth will be presented. Thursday, 11:00 a.m. there will be a panel discussion on "Plastic Service Pipe." Members of the panel will be: James Carns, Max Socha and W. D. Tiedeman. All Meetings will be in the Municipal Auditorium.

F. L. LaQue Heard

(Continued from Page 10)

effect on corrosion by this mechanism.

Where metals are stressed to the point where plastic deformation occurs so as to rupture the relatively noble surface films normally present, the surfaces expand at the points of film rupture. The rupture points become anodic to the surrounding film covered areas and severe corrosion may be induced in the areas of film rupture.

Heat treatment effects in aluminum and copper alloys were also discussed by Mr. LaQue. Attendance at the meeting was 186. This is in contrast with the first joint meeting of these two societies held in 1951. According to an announcement made by NACE's Charles Gribble, the attendance at the 1951 meeting was 80 persons.

POSITIONS WANTED and AVAILABLE

- **Active and Junior NACE members may run without charge two consecutive advertisements annually under this heading, not over 35 words set in 8 point text type.**
- **Firms seeking employees, regardless of NACE membership, may run an advertisement of the same specifications indefinitely.**
- **Advertisements to other specifications will be charged for at standard rates.**

Positions Wanted

Mining-Metallurgical engineer, degree, veteran, married, seeks position. Three year's experience as materials engineer, including welding and corrosion problems, in research and development. Prefer Dallas; will consider any location. Now earning $5400. CORROSION Box 53-4.

•

Instructor cathodic protection, experienced corrosion engineer now employed by large consulting firm desires part time position teaching two-term course, class and laboratory. Outline on request. Location and salary secondary to freedom for private research. CORROSION Box 53-5.

Positions Available

Industrial Sales Engineer—Contacting established account for materials and contracting services for Industrial Coating Specialist, representing a number of large nationally known and progressive principals. Good remuneration. Spray Coat Engineers, Inc., 775 S. Bayside St., Detroit 25, Mich. Vinewood 3-7400.

•

Corrosion Engineers. Positions available for graduate electrical engineers or equal. Previous field and design experience in corrosion mitigation systems required. Extensive travel involved. Salary open. The Hinchman Corp., Engineers, Francis Palms Bldg., Detroit 1, Mich.

•

Chemical Engineer—Familiar with materials of construction and corrosion problems to be technical staff man to evaluate and recommend, also develop methods for mfg. chemical-proof equipment. Advise experience and salary desired. Heil Process Equipment Corp., 12901 Elmwood Ave., Cleveland 11, Ohio.

•

Corrosion Engineer—Major gas transmission company has positions available Tennessee, Kentucky, West Virginia, for engineering graduates with experience in corrosion surveys and cathodic protection. **CORROSION,** Box 53-7.

NACE POLICY ON DUES IN ARREARS

No member of the association with dues in arrears for three months shall receive publications of the association until such dues are paid. Members in arrears one year shall be dropped automatically from membership.

If your dues are not received at Central Office by the latter part of March, you will be dropped from the list to receive NACE publications and mail. Accordingly the March issue of CORROSION will be the last received by those so dropped.

In order to avoid interrupted mail and missed copies of CORROSION members are urged to remit dues before the deadline. Much work will be eliminated at Central Office if members remit before the date stipulated.

WANTED

•

electrical engineer

To supervise the operations and maintenance of Microwave Communications and Cathodic Protection Systems for large pipe line company. Location — Detroit, Michigan. Salary open. Include resume of experience and education together with snapshot. All applications treated as confidential. Corrosion, Box 53-6.

Write for Rates. 1061 M & M Bldg. Houston 2, Texas

CORROSION DIRECTORY

Over 5000 Paid Readers Monthly

Pipe Coating and Wrapping

PIPE COATING "KNOW-HOW"
by PIPE PROTECTION SERVICE, Inc.
Modern Portable Railhead Equipment for Any Size Pipe or Job
Main Plant: 179 FRONT ST., ELIZABETH, N.J.
"The Complete Coating Service"

Testing

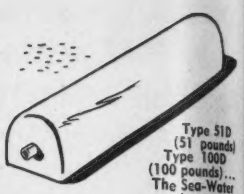
South Florida Test Service
INSPECTION – TESTING – RESEARCH ENGINEERS
(Established 1931)
Corrosion, weathering and sunlight tests. Four locations in Southern Florida for inland, salt atmospheric, tidewater and total immersion exposure tests.
4201 N. W. 7th St. MIAMI, FLORIDA

Water and Steam

WATER SERVICE LABORATORIES, INC.
Specializing Since 1927
Water treatment for corrosion control in buildings, boilers and air conditioning systems.
Main Office—423 West 126 Street, NYC
Offices also in Phila. and Wash., D. C.

at CATHODIC PROTECTION SERVICE . . .

Type 9D (9 pounds)
Type 17D (17 pounds)
Type 32D (32 pounds)

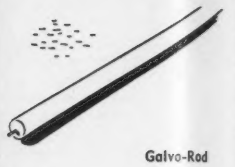


Type 51D (51 pounds)
Type 100D (100 pounds)...
The Sea-Water Anodes

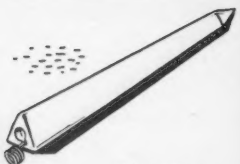
Type 50D (50 pounds)

Type 60DS . . .
The New Ship-Hull Anode

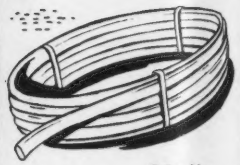
Types 9D, 17D, 32D
Galvo-Pack Units



Galvo-Rod



Galvo-Pile . . .
The New *Driven* Anode



Galvo-Line

DOW MAGNESIUM ANODES

Now Available

CAST TO THE **HIGHEST** PURITY SPECIFICATIONS THE INDUSTRY HAS EVER KNOWN!

All magnesium anodes are now guaranteed to meet the following rigid purity specifications:

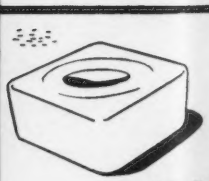
% Al	5.3-6.7	% Cu	0.02 max.
% Mn	0.15 min.	% Ni	0.002 max.
% Zn	2.5-3.5	% Fe	0.003 max.
% Si	0.10 max.	% Other imp.	0.03 max.

% Magnesium—Remainder

It will be noted that the maximum limits have been lowered for the two impurities, copper and nickel, which have proven themselves to be the worst offenders insofar as their effect on current efficiency is concerned—a fact substantiated by published data.

GOOD QUALITY MEANS GOOD ECONOMY

When backfill and installation costs are taken into account, calculation will show that an increase of only 1% in anode efficiency will result in an effective savings of 5% in purchase price of the bare anode.



Galvo-Slab

CPS

OTHER FIRST LINE MATERIALS INCLUDE:

Good-All Rectifiers
CPS Graphite Anodes
Polyken Protective Tape Coatings
Maloney Insulating Materials
Erico Cadweld Welding Materials
Fisher M-Scope Pipe and Cable Locators
Detectron Pipe Locators
Wahlquist Pipe Locators
CPS Graphite Anode Backfills
Homco and Barada and Page Backfills
Agra and Collins Meters
Associated Research Resistivity Meters
Rubicon Potentiometers
Pearson Holiday Detectors
Holloway Shunts
Direct-Burial Cable
Ditch-Witch Trenchers

cathodic protection service

OFFICES LOCATED IN

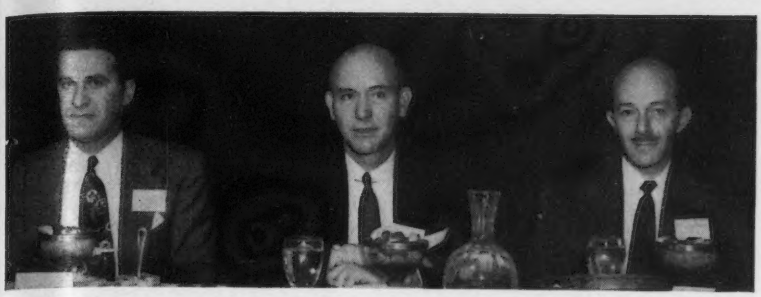
HOUSTON
4601 Stanford Street
Houston 6, Texas
Phone JA-5171

TULSA
314 Thompson Building
Tulsa, Okla.
Phone 2-9857

NEW ORLEANS
1639 Robert Street
New Orleans 15, La.
Phone CH-8310

Everything in the cathodic protection field . . . from an insulating washer to a turnkey contract installation.

Report on Ninth Annual Conference and Exhibition



NACE OFFICERS—Mars Fontana, left, immediate past president; Walter F. Rogers, center, president and Aaron Wachter, right, vice-president are shown here at the annual banquet March 19 at Hotel Sherman, Chicago. Dr. Fontana becomes chairman of the awards committee. Dr. Wachter is coordinating efforts to reorganize the association technical practices commitee

New Officers and Directors Take Reins Of Association at Chicago Conference

Effective with the last day of the 1953 Ninth Annual Conference and Exhibition at the Sherman Hotel, Chicago, new officers and five new directors took over control of the affairs of the National Association of Corrosion Engineers. The new directors include a provisional director for the newly-formed Canadian Region of the association.

Taking office as president on Friday, March 20, were Walter F. Rogers, Gulf Oil Corp., Houston, moving up from the vice-presidency. Aaron J. Wachter, of Shell Development Company, Emeryville, Cal., becomes vice-president while R. A. Brannon of Humble Pipe Line Company, Houston, incumbent treasurer, begins his third year in office. A. B. Campbell of Houston is executive secretary of the association.

M. G. Fontana of Ohio State University, retiring president, assumes the position of past-president. His principal duty is to head the NACE Awards Committee which annually selects the persons to receive the Whitney and Speller Awards.

New directors, representing active members are W. F. Fair, Jr., of Koppers Company, Westfield, N. J., and Robert L. Bullock of Interstate Oil Pipe Line Co., Shreveport, La.

Directors assuming office representing corporate members of the association was J. Pat Casey, Jr., of The Crane Company, Chicago. Derk Holsteyn, with Shell Oil Company, Houston, is the new director representing South Central Region on the board. Robert J. Law, The International Nickel Co. of Canada, Ltd., is provisional director representing the new Canadian division.

The directorship assigned to North Central Region is vacant.

Schmidt Is TP Head

H. W. Schmidt, of Dow Chemical Company, Midland, Mich., was named chairman of the Technical Practices Committee of NACE at the Chicago conference which ended March 20. Mr. Schmidt, who was chairman of the technical program committee for the Chicago meeting, succeeds A. J. Zajac of Shell Oil Co., New York City, who resigned.

MEMBERS AND GUESTS OF CANADIAN REGION are shown here at the first meeting of the newly organized Canadian Region of NACE. The meeting, held March 18, during the Ninth Annual NACE Conference and Exhibition at Chicago, is the first of the annual meetings contemplated by the region. Because of the wide dispersion of Canadian membership it is impractical to attempt to hold more than one meeting annually. In the forefront, left to right are H. P. Godard, Aluminium Laboratories, Ltd., Kingston, Ontario, NACE director; G. I. Russell, Union Gas Co. of Canada, Ltd., Chatham, Ont., region chairman and G. M. McPherson, Imperial Oil Ltd., Calgary, Alta, region secretary-treasurer.

Busy Week Attracts 1575 Registrants To Chicago Meeting

Registration at the Chicago NACE conference which ended March 20 was 1575. Of this number 113 were women and 40 were registered Friday, the last day of the meeting, after the registration had ended officially. This number is approximately 200 greater than the number who registered at the NACE's Galveston Conference in 1952.

Approximately 800 exhibitors' guests were counted in addition to the number registered. This year's meeting was the first at which a system was used permitting a count of persons attending the exhibition only.

The meeting was characterized by well-attended committee and technical sections and by the largest and most varied exhibition the association has had. New offerings on the technical program were well attended. Three lectures on the fundamentals of corrosion were popular. The first lecture by R. B. Hoxeng of United States Steel Corp., was given before an audience in which many were standees. Two other lectures on fundamentals were well received and attended.

Featured also as part of the technical program were four items devoted to the interests of the pipe line industry—three discussion sessions and one symposium of prepared papers. These, as is customary at NACE meetings, were well attended.

There were eight other symposia. A total of 42 papers was presented in all.

Friday technical sessions were not as well attended as other sessions, according to H. W. Schmidt, technical program chairman. He indicated shifting the round table sessions to an earlier time during the week probably accounted for this.

Excellent attendance at the three educational lectures and at the opening symposium on corrosion principles indicates a significant interest in the theoretical aspects of corrosion science, Mr. Schmidt said. He asserted full recognition of this should be taken in planning future sessions and that the frequently heard contention that theoretical sessions are unpopular apparently is not sustained by the experience of NACE.

Good interest and attendance at the technical events arranged for pipeliners was reported. Of the four principal technical program items of special interest to pipeliners, the concensus seems to be that the small group discussions held under the guidance of A. L. Stegner of Tennessee Gas Transmission Company were most productive of real benefits. These sessions attracted five groups of 30 to 40 each. As is customary no record of proceedings at pipeliners' discussion sessions was kept.

•

Lists of material published for resale by NACE may be obtained by writing to Central Office, 1061 M & M Bldg., Houston 2, Texas.

For textile mills, steel mills and chemical plants...

LEADING ENGINEERS CHOOSE SARAN RUBBER*-LINED PIPE!

To solve pipeline corrosion, MICHIGAN SARAN RUBBER-LINED STEEL PIPE offers the highest degree of resistance to corrosive chemicals, oils, acids and gases. Available in either fabricated light gauge steel or standard steel pipe in regular 10' and 20' lengths ranging in size from 8" up...or fabricated to your exact requirements.

For additional information write to your MPC representative or to our Application Engineering Dept. C

*Saran Rubber is a development of the Dow Chemical Company

mpc

MICHIGAN PIPE COMPANY

BAY CITY, MICHIGAN

TP-1 on Corrosion of Oil and Gas Well Equipment is shown here during its meeting at Hotel Sherman, Chicago during the Ninth Annual Conference. Presiding are H. L. Bilhartz, Atlantic Refining Co., Dallas and R. C. Buchan, Humble Oil & Refining Co., Houston, committee chairman and vice-chairman, respectively. Mr. Buchan was elected chairman succeeding Mr. Bilhartz and E. C. Greco of United Gas Corp., Shreveport, La. was named vice-chairman.

23 Technical Practices Committee Meetings Are Held; Reorganization Plan Is Studied

Sustained Growth of Association Cited in Committee Reports

The sustained growth of the National Association of Corrosion Engineers during the past twelve months was underlined in reports of officers and standing committee heads at the association's annual general business meeting March 17. The meeting was held at Hotel Sherman, Chicago, during the Ninth Annual Conference and Exhibition of the association.

Most significant evidence of NACE growth probably was that given by L. A. Baldwin, of Johns-Manville Co., New York, chairman of the association's Regional Management Committee when he predicted the association would have 34 organized sections by the end of the conference, March 20. This would be an increase of eight sections during the preceding twelve months. Four of the new sections, at Vancouver, B. C., Toronto, Montreal and Hamilton are in Canada, a newly organized region of NACE, in which association membership has more than trebled in a year.

A report by R. A. Brannon, Humble Pipe Line Co., Houston, showed the association to be in good financial condition, while A. B. Campbell, executive secretary, outlined some of the events occurring in the association during the year.

Reports were made also by R. B. Hoxeng, United States Steel Corp., Pittsburgh, chairman of the publication committee; E. P. Noppel, Ebasco Services, New York, chairman of the policy and planning committee, and M. G. Fontana, Ohio State University, Columbus, president. Committee chairmen from the Chicago conference were introduced.

•

NACE sells subscriptions on a calendar year basis of McBee punch cards on which are printed abstracts of corrosion literature published in more than 500 periodicals at home and abroad. More than 2000 cards are issued annually. They are pre-indexed according to the punch card index system by topics, periodical in which published, first and second authors, and year.

Twenty-three meetings of Technical Practices Committee subcommittees were held during the Ninth Annual Conference and Exhibition held March 16-20 at Chicago.

The groups holding meetings were:

TP-1—Corrosion of Oil and Gas Well Equipment.
TP-1D—Sour Oil Well Corrosion.
TP-1G—Sulphide Corrosion Cracking.
TP-2—Galvanic Anodes for Cathodic Protection.
TP-4—Minimum Current Requirements for Cathodic Protection.
TP-5—Corrosion Problems Involved in Processing and Handling Chemicals.
TP-5D—Corrosion by Organic Acids and Bases.
TP-5F—Corrosion by Chlorine.
TP-5G—Corrosion by Nitric Acid.
TP-6G—Surface Preparation for Organic Coatings.
TP-6E—Protective Coatings in Petroleum Production.
TP-7—Materials for Use at High Temperatures.
TP-9—Corrosion Inhibitors.
TP-11—Identification of Corrosion Products.
TP-12—Effect of Electrical Grounding on Corrosion.
TP-14—Instruments for Corrosion Measurements.
TP-15A—Corrosion Control of Railroad Tank Cars.
TP-16—Electrolysis and Corrosion of Cable Sheaths.
TP-16B—Corrosion of Lead and other Metallic Sheaths.
TP-17—Standardization of Procedures for Measuring Pipe Coating Conductance.
TP-18A—Internal Sour Crude Corrosion of Pipe Lines and Tanks.
TP-18B—Internal Corrosion of Products Pipe Lines.
TP-19—Corrosion by Deicing Salts.

Aaron Wachter of Shell Development, Emeryville, Cal., NACE vice-president, who has been named chairman of a committee to prepare recommendations for reorganization of the NACE's technical committees, told the board of directors March 20 his first inquiries have developed the following significant facts:

1. A procedural manual for guidance of the committees is urgently needed.
2. Organization of the subcommittees on industry lines seems to be the best from the standpoint of orderly procedures and best results.
3. Adoption of specific limited objectives by the subcommittees will lead to more useful discoveries in the shortest time.

TESTED AND PROVED

"COPON", the new Coast-formulated epon resin coating for positive protection of metal surfaces . . .

"COPON" is now giving industry a truly remarkable new kind of protection against rust and corrosion from chemical fumes, acids, caustic alkali and salt water. And it is combining its revolutionary protective qualities with other such desirable features as (a) remarkable elasticity, (b) exceptional long life, (c) phenomenal tenacity to all types of metals.

May we give you more facts — or send you sample for your own testing?

Available in Primers, Finishing Enamel and Paints in all Colors.

CPL

COAST Paint & Lacquer Co. Inc.

P. O. BOX 1113 • HOUSTON, TEXAS

INTER SOCIETY CORROSION COMMITTEE members are shown here at their meeting at Hotel Sherman, Chicago during the Ninth Annual NACE Conference. The committee now has 32 member organizations among technical groups conducting corrosion work. Presiding at the head of the table is H. P. Godard, Aluminium Laboratories, Ltd., Kingston, Ont., chairman. Seated at his left is A. B. Campbell, NACE executive secretary, who is also secretary of the committee.

AT LAST! AN ECONOMICAL, SHOCK RESISTANT INSULATING COUPLING

Until recently mechanical weakness and high costs have discouraged the large-scale use of insulating couplings on gas distribution systems. Now comes PESCO . . . *safe*, economical, rugged, easy to install, and assuring permanent electrical insulation.

Insulate your distribution system with

PESCO INSULATING COUPLINGS

PESCO couplings are designed and built to stand up under all types of extreme operational conditions. They are molded of nylon under high pressure. Nylon is a thermoplastic resin which is comparable to thermosetting resins in physical properties and far superior in chemical resistance and the ability to withstand *bending, side thrust and shock*. They stand pressures up to 1100 psi in the ¾" and 1" sizes and are not affected by temperatures up to 300°F. Molding forms perfect threads and a "di-electric wall" inside the coupling to provide foolproof electrical insulation and added sealing ability. A special locking device prevents the coupling from turning or slipping in its steel sleeve.

PESCO couplings may be installed by your regular workmen with their standard operating procedures. Available in all sizes from ¾" to 2".

PLASTIC ENGINEERING AND SALES CORP.

P. O. BOX 1037 FORT WORTH, TEXAS

Glossary of Corrosion Terminology Is Started By ISCC Group

Under direction of the Inter Society Corrosion Committee, a committee sponsored by the National Association of Corrosion Engineers and consisting of representatives of 32 societies and organizations doing corrosion work, a glossary of corrosion terminology and definitions is being compiled. This was reported by Hugh P. Godard of Aluminium Laboratories, Ltd., Kingston, Ont., to the general business meeting of NACE March 17 at the Sherman Hotel, Chicago.

Mr. Godard also said two members had been added to the committee during the year, the American Ordnance Association and the Society of Naval Architects and Marine Engineers. He also said, in outlining the functions of the committee, that close relations have been established with the Corrosion Committee of the Society of the Chemical Industry in England.

Reports submitted to the committee, Mr. Godard pointed out, were being prepared according to a standard form this year, which should improve the quality and usefulness of the information thus provided.

Mail Canvass of Exhibitors Is Planned

Collection and evaluation of comments by exhibitors on the recently concluded NACE Ninth Annual Conference and Exhibition at Chicago was authorized by the association's board at a meeting March 20 in Chicago. A canvass of exhibitors by mail is scheduled.

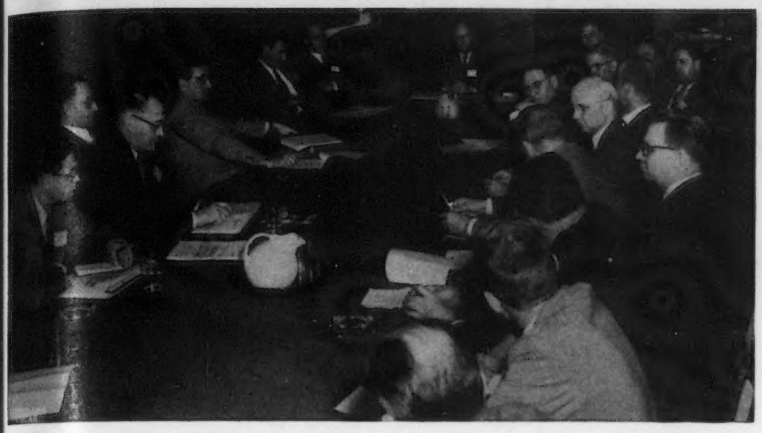
The decision followed reports by A. W. Smith of Dearborn Chemical Company, 1953 Exhibits chairman, in which the principal informal comments on the conference by exhibitors were reported. Mr. Smith said there was general dissatisfaction with the regulations limiting access to the exhibits of persons not registered who did not wish to attend technical sessions.

Following discussion by the board it was decided provision of tickets for admission to exhibits would be liberalized, especially when the meeting is being held in large metropolitan areas.

NACE Cooperation in Short Courses Approved

The National Association of Corrosion Engineers' Executive Committee at a March 15 meeting at Chicago approved participation by NACE in a short course on corrosion scheduled to be given by the University of California, Berkeley, in the spring of 1954. The approval was given prior to the opening of the Ninth Annual Conference and Exhibition of NACE at Hotel Sherman.

According to information made available to the executive committee by Chairman Norman Hackerman of the association's committee on education the university plans a course on marine corrosion which will include some or all of the following topics: Paint, biological corrosion, corrosion of tankers, corrosion of offshore oil rigs, pilings, offshore pipe lines and corrosion of laid up ships.



TP-19 on Corrosion by De-Icing Salts held a meeting at Sherman Hotel, Chicago during the Ninth Annual Conference. F. E. Kulman, chairman is shown at the head of the table presiding.

Dunnington and Beck Get 1952 Junior Award For Best Technical Paper

Dr. Bruce W. Dunnington, with Atomic Energy Div., E. I. Du Pont de Nemours & Co., Inc., Wilmington, Del., and Dr. Franklin H. Beck, Assistant Research Professor, Engineering Experiment Station, Ohio State University, Columbus, were given the 1952 NACE Junior Author Award at the annual association banquet at Chicago. They were co-authors with M. G. Fontana, of the paper "The Mechanism of Scale Formation on Iron at High Temperature," which was judged best of the 23 papers considered. Dr. Fontana was ineligible on account of age. The award, funds for which were provided by an anonymous donor, is made annually to the author or authors under 35 years of age, whose paper is judged most meritorious.

George Diehlman of National Lead Co., New York City, was chairman of the award committee and made the presentation. The committee gave honorable mention to the paper by J. P. Fraser and R. S. Treseder of Shell Development Co., Emeryville, Cal., entitled "Cracking of High Strength Steels in Sulfide Solutions."

Two Regions' By-Laws Considered by Board

By-laws of South Central and Canadian Regions were approved with amendments recommended by the association's policy and planning committee by the NACE board of directors at a meeting March 20 at Chicago. The amended by-laws were ordered forwarded to the officers of the two regions.

The policy and planning committee of which E. P. Noppel of Ebasco Services, New York City is chairman, also is working on preparation of a set of model regulations for sections. When completed the regulations will be for the guidance of sections of the association.

•

Indices to each volume of CORROSION are published in the December, the twelfth and last issue of each year.

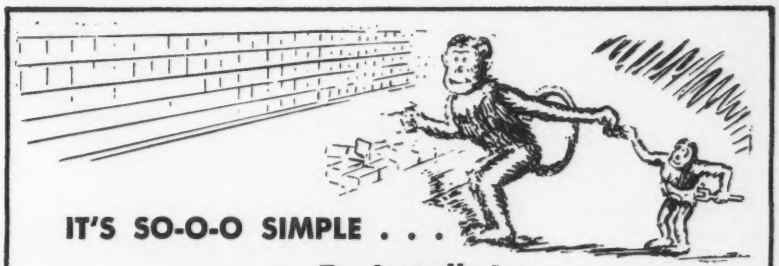
Heads of Kansas City Meeting Lay Plans

At a meeting at the Sherman Hotel, Chicago, March 15, chairmen of the principal conference committees for the Tenth Annual Conference and Exhibition of the National Association of Corrosion Engineers to be held at Kansas City, Mo., in March, 1954, and of the Chicago 1953 conference discussed the functions of their committees. Heads of the committees responsible for the Chicago meeting outlined the manner in which they conducted their work and made suggestions to the committeemen for next year's meeting.

Attending this meeting were the following officials of the 1954 meeting: Harry K. Phipps, Socony-Vacuum Oil Co., Inc., Wichita, Kans., chairman of the general conference committee; F. L. Whitney, Jr., Monsanto Chemical Company, St. Louis, chairman of the technical program committee; O. E. Murrey, Midwestern Engine & Equipment Co., Tulsa, chairman of the exhibits committee, and C. C. Keane, Great Lakes Pipe Line Co., Kansas City, Mo., chairman of the local arrangements committee.

Committee heads for the Chicago meeting attending were H. L. O'Brien, Graver Tank and Mfg. Co., Inc., East Chicago, Ind., general conference committee chairman; H. W. Schmidt, The Dow Chemical Company, Midland, Mich., technical program committee chairman; Carl B. Smith, Dearborn Chemical Co., Chicago, exhibition committee chairman, and L. W. Ewing, Standard Oil Co. of Indiana, Chicago, local arrangements committee chairman.

NEWS FOR MAY CORROSION Should be at CENTRAL OFFICE Houston Before April 10



IT'S SO-O-O SIMPLE . . .

To Install An

INSULATED GASKET UNION

The Insulator You Have Been Searching For!

- Metal to Metal Threads
- Perfect Electrical Insulation
- 300# W. O. G.
- Will Not Break
- All Insulating Parts in Compression
- No Field Education Required
- Electrically and Pressure Tested

Sizes ½" - 3" Inclusive

SERVICE ENGINEERS, INC.

Manufacturers of Industrial Plastic Products

3030 W. Pafford P. O. Box 11068 Fort Worth 9, Texas

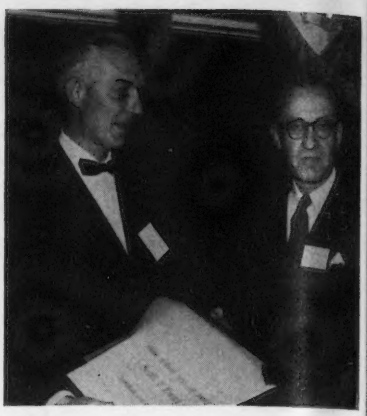
Ewing and Burns Receive Annual Awards

The 1953 Speller and Whitney Awards of the National Association of Corrosion Engineers have been given to Scott P. Ewing, with Carter Oil Company, Tulsa, and R. M. Burns, with Bell Telephone Laboratories, Murray Hill, N. J., respectively. The awards were made at the association's annual banquet on the night of March 19 at the Sherman Hotel, Chicago, during the NACE Ninth Annual Conference and Exhibition.

Presentation of the awards was by N. E. Berry, Servel, Inc., Evansville, Ind., immediate past president of the association and chairman of its awards committee. Mr. Ewing has devoted more than 25 years to the study of underground and marine corrosion, while Mr. Burns, who has held responsible positions in the Bell Laboratories for more than two decades, has held and currently holds offices in The Electrochemical Society and is active in other professional societies.

•

Manuscripts of material on corrosion are accepted without invitation for review by NACE. Authors are advised to secure in advance of preparing their manuscripts a copy of the publication "Guide for the Preparation and Presentation of Papers," sent free.



SCOTT P. EWING, Carter Oil Company, Bartlesville, Okla., receives the annual Speller Award from N. E. Berry, Servel, Inc., Evanston, Ind. chairman of the NACE Awards Committee. Presentation was made at the annual banquet of the association at Hotel Sherman, Chicago, March 19. The award is made annually for achievement in the field of corrosion engineering.

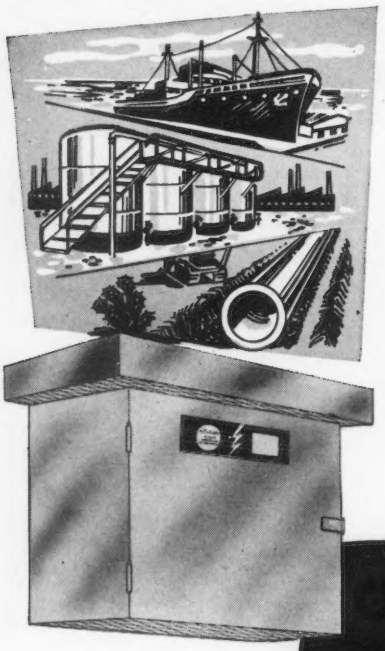
ROBERT M. BURNS, Bell Telephone Laboratories, Murray Hill, N. J. accepts the annual Whitney Award for achievement in corrosion science from N. E. Berry, chairman of the awards committee. Mr. Burns, in his acceptance address, urged engineers to take part personally in current efforts being made to increase the number of students entering the engineering fields. A long-standing and continuing deficit of trained engineers is a serious problem for the nation, Mr. Burns said.

Added Features for Corrosion Planned

Additional features for the technical section of Corrosion magazine are planned, R. B. Hoxeng, chairman of the association's publication committee reported to the board of directors March 20. One of these to be under the designation "Technical Notes" will cover developments not of sufficient magnitude to justify preparation of a formal paper. The other to be designated "Research and Progress" will consist of brief items on the research programs now under way into corrosion subjects at many university and other laboratories.

•

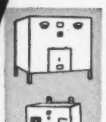
Constructive discussions on technical material published in Corrosion are welcomed.



FIGHT CORROSION
with SPECIAL EQUIPMENT to meet YOUR NEEDS

Cathodic Protection from a Dependable D C source

RICHARDSON ALLEN SELENIUM RECTIFIERS

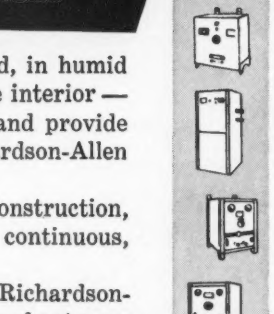


Whether it's overhead or underground, in humid or dry atmosphere, on the seacoast or in the interior — combat corrosion with cathodic protection and provide for utmost dependability by installing Richardson-Allen Selenium Rectifiers.

A sound basic design with high quality of construction, and many features of superiority assure continuous, uninterrupted service.

Let us prove to you the dependability of Richardson-Allen equipment for your application. Tell us about your present needs and let us submit a quotation.

RICHARDSON-ALLEN CORPORATION
a manufacturing affiliate of
WESLEY BLOCK AND COMPANY, 39-15 MAIN ST., FLUSHING, N. Y.
IN CANADA: Richardson-Allen of Canada, Ltd., 370 Victoria St., Toronto, Ont.



SET IT and FORGET IT

1955 Conference Is Switched to Chicago

Following a report from A. L. Donovan, Consolidated Edison Co. of New York, the NACE board of directors at a meeting March 20 at Chicago authorized A. B. Campbell, executive Secretary, to complete arrangements for holding the 1955 conference and exhibition of the association at Palmer House, Chicago. The meeting probably will be held the week of March 6, somewhat earlier than the association has recently held its annual meetings.

The change to Chicago for the 1955 annual meeting resulted from Mr. Donovan's report which indicated no suitable dates were open at New York for the 1955 meeting. It previously had been decided to hold the annual meeting there.

The board was inclined also to favor holding the 1956 annual meeting in the North East. An investigation of the open dates at various places will be made.

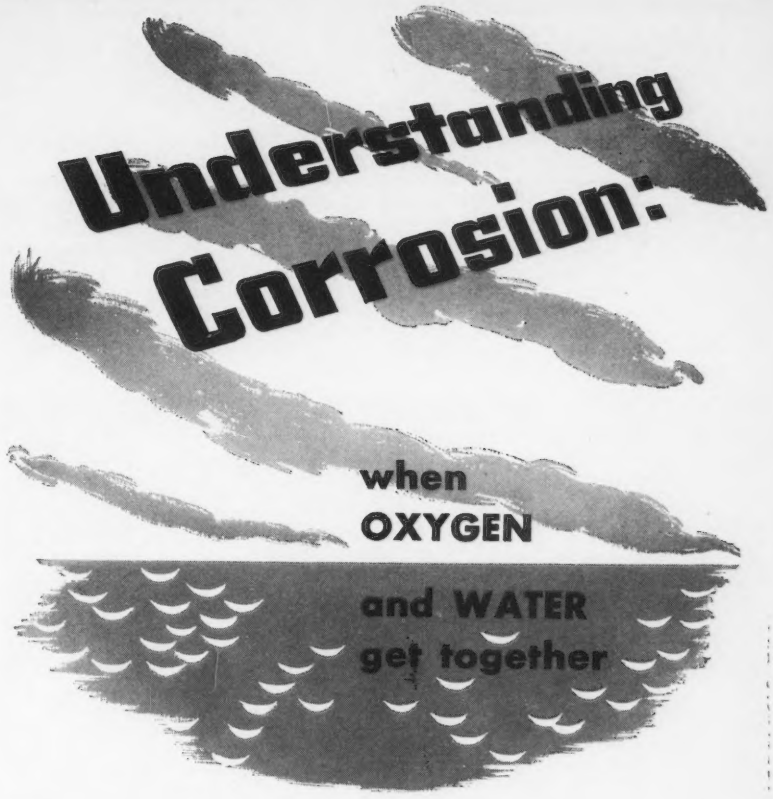
Three Members Added To Editorial Review Committee of NACE

Three new members have been added to the NACE Editorial Review Committee, a new chairman has taken over and one committee member has retired. This leaves the group with a net of seven members, an increase of two. The committee reviews the technical manuscripts submitted for publication in CORROSION.

New members are I. C. Dietze, of the Department of Water and Power, City of Los Angeles; J. J. Harwood, Office of Naval Research, Washington, D. C. and V. B. Pike, Bell Telephone Laboratories, Murray Hill, N. J. Mr. Dietze is chairman of Technical Practices Committee 16 on Electrolysis and Corrosion of Cable Sheaths. Mr. Harwood and Mr. Pike have contributed technical papers for publication in CORROSION and have been active otherwise in the NACE.

The new chairman, Thomas P. May, a member of the editorial review committee for many years, succeeds George Diehlman, who is in the Research Laboratories of the National Lead Company, New York City. Mr. May is in the Corrosion Engineering Section of The International Nickel Co., Inc. at New York City. Both have contributed technical material to CORROSION in their respective fields.

The NACE Editorial Review Committee annually reviews about 100 technical manuscripts submitted to the association for publication in CORROSION. The committee calls on experts in the various corrosion fields involved to assist in determining whether or not a paper merits publication. The responsible committee member then presents the consensus of the reviewer's and his own opinion to the chairman, who in turn transmits this consensus together with his own views to the editor of CORROSION who decides whether the paper will or will not be published.



When free oxygen combines with atmospheric moisture or natural waters, the stage is well set for corrosive action. Controlling the degree and extent of that action are many related factors, variable in influence under differing circumstances.

The rate at which oxygen is transferred from atmosphere to a solution is, for example, directly proportional to the amount of exposed surface area of that solution, while the corrosion rate of immersed metal is, in turn, proportional to the oxygen concentration of the solution. Therefore, with all other factors stabilized, a reduction in exposed surface area will slow the oxygen-solution process, thereby greatly retarding corrosion.

How deeply metal is immersed, particularly in a quiet solution, is another determinant of corrosive action in which dissolved oxygen is the governing factor. Oxygen saturation, highest at and near the surface, diminishes with increasing depth as convection currents become less active. Corrosion at and immediately below the surface of a liquid is therefore far more severe than that encountered at greater depths.

These and other variables that combine to produce a given corrosion problem must be evaluated in any attempt to reach an effective and practical solution. Such evaluation, based on thirty-five years' corrosion-control experience, is standard Dampney procedure. That is why your specification of a Dampney Coating assures you so much *more* — protection you can depend upon to meet not only standard industrial service requirements but your specific equipment-operating needs. For data on Dampney Protective Coatings and their place in your corrosion-control program, write

MAINTENANCE FOR METAL

THE DAMPNEY COMPANY

158-1 HYDE PARK, BOSTON 36, MASSACHUSETTS

Yearbook Publication Is Weighed by Board

Publication of a yearbook by the National Association of Corrosion Engineers in 1954 was approved in principle by the association's board of directors at Chicago. The publication committee was authorized to prepare a proposal, including cost data, for consideration by the board at its December meeting.

R. B. Hoxeng, publication committee chairman, who made the recommendation to the board, pointed out the unsatisfactory situation which exists as a result of the current policy of including the annual directory of membership of the association in Corrosion magazine. The fact also that the committee directory, for example, is customarily mailed only to members of the technical practices committee, was also cited as a factor in coming to the decision a yearbook would be desirable. For several years the publication committee has been recommending that the membership directory be published separately from Corrosion magazine.

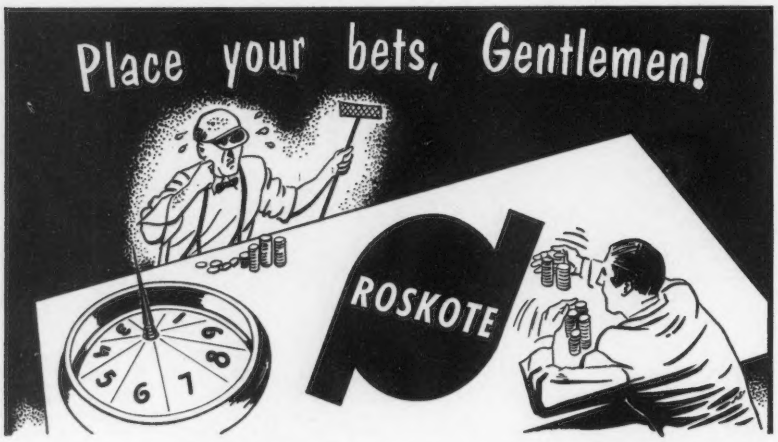
Mr. Hoxeng proposed, and the board substantially approved, the following points respecting the proposed yearbook:

1. It would include the membership directory, committee directory, map and list of sections and regions, description of annual awards, list of current publications, articles of organization and bylaws, a summary of accomplishments of technical practices committees and a brief history of the association.

2. It would be distributed free to all members in good standing at time of publication.

Mr. Hoxeng also pointed out the value of such a yearbook to persons soliciting corporate memberships in that it gave under one cover most of the information available about NACE.

A cost estimate and recommended format will be prepared for presentation to the board in December.



...On ROSKOTE, of course — that's the one safe bet for complete pipe protection.

Roskote is applied *cold*. That means money saved by elimination of kettles and man-hours by faster operation and reduced hazards.

Roskote is fast drying. It dries to the touch in 20 minutes and is ready for backfill in an hour. That means money saved by speeding pipeline progress.

Roskote is ready to apply — by brush or spray — and bonds firmly to bare pipe or previous coatings. That's money saved by elimination of priming coat and field mixing or thinning.

Roskote retains its tough flexible film, without brittleness or sag through a temperature range of −40° to 375° F. It provides an electrical resistivity of 20 megohms per square foot. It is resistant to acid, alkali, salt and moisture.

Roskote is specified by more than 80 utilities and pipeline companies for coating pipelines, "hot spots", joints, road crossings, valves, meters, drips; for patching and for waterproofing concrete regulator pits.

For complete information, technical data and free samples of Roskote and Royston Glas-Wrap write:

Ask about the Roskote-Glas-Wrap reinforced pipeline protection against mechanical abrasion and the really tough jobs.

ROYSTON
LABORATORIES, INC.,
P. O. Box 112-C
BLAWNOX, PA.

MANUFACTURERS OF QUALITY INDUSTRIAL COATINGS RESISTANT TO CORROSION BY ACIDS, ALKALIES, ELECTROLYSIS, HEAT, MOISTURE AND WEATHER.

Improvements Voted For Punch Card Service

Effective as soon as NACE Central Office can carry it out, punch cards provided under the NACE Abstract Punch Card Service will be supplied with the topical field pre-punched at Central Office. No additional charge for this service will be made, the NACE board of directors decided in approving the recommendation the punching be done. R. B. Hoxeng, United States Steel Corp., Pittsburgh, chairman of the NACE publication committee, recommended this action to the board upon suggestion of the association's abstract committee.

The cards now are being delivered with the coding indicated but not punched. The punching of the topical field will help to meet the principal demand by subscribers many of whom have found it impractical to punch the cards themselves.

Widening interest in the association's punch card and other abstract services was evidenced by the number of persons who inspected the working segment of the card system at the NACE booth at Chicago. Mrs. Claudia Hayward, who is in charge of the service, reported considerable interest in the system, which she explained to visitors at the booth.

Publication Speed-Up Due on Bibliographies

An ambitious schedule for the publication of volumes of the Bibliographic Survey, the biennial compilations of abstracts of corrosion literature published by the National Association of Corrosion Engineers has been recommended. The schedule, presented to the association's board of directors at its March 20 meeting at the Sherman Hotel, Chicago, by R. B. Hoxeng, publication committee chairman, calls for publication of the volume containing abstracts of literature appearing in 1948 and 1949 this year; publication of the volume containing 1950 and 1951 abstracts in 1954 and publication of the volume containing the 1952-53 abstracts in 1955. Completion of this program would bring the association's abstract publications substantially up to date. There is a normal lag of about two years between publication of an article and the completion of the abstract compilation.

Mr. Hoxeng also proposed that the 1954 Bibliographic survey include a 10-year index to NACE abstracts.

Mr. Hoxeng also pointed out that a prerequisite to compilation of the 10-year index was a reclassification of the 1945 volume of abstracts which is indexed by a system different from that currently used by the association.

Corrosion Abstracts

NATIONAL ASSOCIATION OF CORROSION ENGINEERS

Index to CORROSION ABSTRACTS

Vol. 9 March, 1953 No. 4

	Page
1. GENERAL	
1.2 Importance	49a
1.6 Books	49a
1.7 Organized Studies of Corrosion	50a
2. TESTING	
2.1 General	50a
2.2 On Location Tests	50a
2.3 Laboratory Methods and Tests	52a
2.4 Instrumentation	54a
3. CHARACTERISTIC CORROSION PHENOMENA	
3.2 Forms	54a
3.3 Biological Effects	56a
3.4 Chemical Effects	56a
3.5 Physical and Mechanical Effects	57a
5. PREVENTIVE MEASURES	
5.2 Cathodic Protection	58a
5.3 Metallic Coatings	60a
5.4 Non-Metallic Coatings and Paints	60a
5.5 Oil and Grease Coatings	63a
5.6 Packaging	63a
5.7 Treatment of Medium	63a
5.8 Inhibitors and Passivators	64a
6. MATERIALS OF CONSTRUCTION	
6.3 Non-ferrous Metals and Alloys—Heavy	66a
6.4 Non-ferrous Metals and Alloys—Light	66a
7. EQUIPMENT	
7.1 Engines, Bearings, and Turbines	66a
7.2 Valves, Pipes and Meters	67a
8. INDUSTRIES	
8.1 Group 1	68a
8.5 Group 5	69a
8.8 Group 8	69a
8.9 Group 9	69a

Investigate Other Abstract Services Offered by NACE!

Abstract Punch Card Service.

Corrosion abstracts printed on McBee Punch Cards, pre-indexed by the NACE Filing system with up to 4 cross-references. Write for full information.

NATIONAL ASSOCIATION of CORROSION ENGINEERS

1061 M & M Bldg. Houston, Texas

1. GENERAL

1.2 Importance

1.2.2, 7.5.5, 8.4.3.

Economics of Metals and Coatings to Combat Corrosion of Refinery Tank Roofs. H. F. McConomy and J. J. Hur, Atlantic Refining Co. Paper before Am. Petroleum Inst.'s Div. of Refining, 17th Ann. Mtg., San Francisco, May 13, 1952. *Petroleum Refiner*, **31**, No. 5, 124-126 (1952) May.

An evaluation of the expenditure incurred by the replacement of steel refinery tank roofs destroyed by internal corrosion includes: 1) tank cleaning costs, 2) preparation and miscellanous maintenance, 3) repairs to roof or application of coating, 4) company overheads, 5) downtime and 6) rate of return (or interest) on additional investment. Materials chosen for comparison were bituminous-base and organic resin-base protective coatings on 3/16 in. steel plate, heavier ¼ in. steel plate, galvanized 3/16 in. steel plate and 3/16 aluminum plate. Tables, results, summary, conclusion and three references are included.—INCO.

1.6 Books

1.6

Corrosion Guide. E. Rabald. **1951**, 629 pp. Elsevier Publishing Co. Inc. Distributed in the British Commonwealth except Canada by Cleaver-Hume Press Ltd.,

PHOTOPRINTS and/or MICROFILM COPIES

of Technical Articles Abstracted in

CORROSION ABSTRACTS

Can Be Obtained From

ENGINEERING SOCIETIES LIBRARY, 29 West 39th Street, New York 18, N. Y.

CARNEGIE LIBRARY OF PITTSBURGH, 4400 Forbes St., Pittsburgh 13, Pa.

NEW YORK PUBLIC LIBRARY, New York City.

U. S. DEPT. OF AGRICULTURE LIBRARY, Office of Librarian, Washington, D. C. (Special forms must be secured).

LIBRARY OF CONGRESS Washington, D. C.

JOHN CRERAR LIBRARY 86 East Randolph St., Chicago 1, Ill.

Persons who wish to secure copies of articles when original sources are unavailable, may apply directly to any of the above for copies. Full reference information should accompany request. The National Association of Corrosion Engineers offers no warranty of any nature concerning these sources, and publishes the names for information only.

NACE will NOT accept orders for photoprint or microfilm copies of material not published by the association.

CODE OF AGENCIES SUPPLYING CORROSION ABSTRACTS

AER—Aeronautical Engineering Review, Institute of Aeronautical Sciences, Inc. 2 East 64th St., New York 21, N. Y.

ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Onatrio, Canada.

AWWA—Journal, American Water Works Association. Amer. Water Works Assoc., 521 Fifth Ave., New York 17, N. Y.

BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

BTR—Battelle Technical Review, Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.

BNF—Bulletin; British Non-Ferrous Metals Research Association. 81-91 Euston St., London NW 1, England.

CALCO—Calco Chemical Division, American Cyanamid Corp. Bound Brook, New Jersey.

CE—Chemical Engineering, McGraw Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

CEC—Consolidated Edison Co. of New York, Inc. 4 Irving Place, New York 3, New York.

EL—Electroplating. 83/85 Udney Park Road, Teddington, Middlesex, England.

EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

GPC—General Petroleum Corp. of California. 2525 East 37th St., Los Angeles 11, Calif.

INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.

IP—Institute of Petroleum. 26 Portland Place, London W#1, England.

JSPS—Japan Society for the Promotion of Science, Address: Mr. Hayata Shigeno, Secretary, Committee of Preventing Corrosion, c/o Government Chemical Industrial Research Institute, 1-Chome Nakameguro, Meguro-ku, Tokyo, Japan.

MA—Metallurgical Abstracts, Institute of Metals, London, England. 4 Grosvenor Gardens, London SW 1, England.

MI—Metallurgia Italiana. Associazone Italiana di Metallurgia. Via S. Paola, 10, Milano, Italia.

MR—Metals Review, American Society of Metals. 7301 Euclid Ave., Cleveland 3, Ohio.

NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.

NBS—National Bureau of Standards. Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.

NSA—Nuclear Science Abstracts. United States Atomic Energy Commission, Technical Information Division, Oak Ridge, Tenn.

PDA—Prevention Deterioration Abstracts. National Research Council, 2101 Constitution Ave., Washington 25, D. C.

RA—Refrigeration Abstracts, American Society of Refrigeration Engineers. 40 West 40th St., New York 18, N. Y.

RM—Revue de Metallurgie, Paris, France. 5 Cite Pigalle, Paris (9e), France.

RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London. Waldegrave Rd., Teddington, Middlesex.

SE—Stahl Und Eisen, Verlag Stahleisen, M. B. H., Dusseldorf, August-Thyssen Str. 1. Postscheck Koln 4110, (22a) Dusseldorf, Germany.

TIME—Transactions of Institute of Marine Engineers. 85 The Minories, London EC 3, England.

UOP—Universal Oil Products. 310 South Michigan Ave., Chicago, Illinois.

ZDA—Zinc Development Association. Lincoln House, Turl Street, Oxford, England.

42a South Audley St., London, W.1. £4 10s.

After a brief introductory discussion including the principles of corrosion and methods of corrosion resistance measurement, the great bulk of this book is devoted to tables showing the behavior of forty metals, alloys and non-metallic materials towards some two hundred and fifty corrosive agents. The number of materials whose corrosion behavior is considered shows that the range is restricted: thus, brasses are listed under the heading 60-90% Cu, while no cupronickels are included (only Monel among the non-ferrous nickel alloys) and there is no systematic reference to zinc or its alloys. The selection of corroding agents is quite impressive, though obviously the heading "atmosphere" is not likely to throw a great deal of light on the behavior of materials in air. As a general guide, this book will help people to clear their ideas about materials to be used in particular circumstances.

The tables (which form almost the entire bulk of the book) are set out so that the corroding media appear on flap attachments which can be turned outwards, while the corrodants and their effects are set out across the pages. Behavior of materials is indicated usually by various signs (which hardly provide a sufficient range) or by short notes. While this may be convenient for reference, it inevitably leads to very large areas of blank paper, including numerous places where no information is available; it has greatly increased the amount of paper used and complicated the production of the book, thus much increasing the cost.

1.6, 3.6.1

Electrochemical Data. By B. E. Conway, The Chester Beatty Research Institute, London. 374 pages plus xx. 6 x 9, cloth. **1952,** The Elsevier Press, Inc., 402 Lovett Blvd., Houston. $8.75.

Data are accumulated which are not generally available in other handbooks. Author begins with a treatment of universal constants and ratios and some conversion factors vital to workers in the electrochemical field. A group of tables and data gives general information on physical properties which are relevant to the electrochemistry of solids and solutions. Molecular and ionic interaction in the liquid phase are elaborated and data given on activity coefficients, osmotic coefficients, hydration, salting out and salting in of strong electrolytes in aqueous and non-aqueous solutions and mixtures.

One chapter of tables deals with transport in solutions of strong electrolytes, electrolytic migration and diffusion.

Several pages of data are given on dissociation constants, solubilities and buffer solutions including ionic equilibria, electric double layer at interfaces, transport of colloids and melts.

Final chapters deal with electrode processes, principally those which are reversible and with parameters of electrode kinetics. A topical index is included.

1.6, 5.3.1, 5.4.1

Finishing Handbook and Directory, 1951. W. J. Roberts. Sawell Publications Ltd., London, xxii + 246 pp. Price 15/-.

Overall this is a very useful handbook containing information on a wide variety of topics including preparatory treatments, painting processes, electroplating, light-alloy finishing and wood finishing. However, the sections are by no means uniform in quality or at least it seems so to us, and doubtless the judgment on a particular chapter will vary according to the reader. Thus, the section on plating, about which our capacity for judgment may be questioned, appears to be factual and of considerable practical utility. On the other hand, the paint section is discursive and some of the arguments are fallacious, although it has clearly been written by a man with a good practical background. Judicious editing would have easily improved the paint section immensely. The finishing directory, Section 3, is usually comprehensive; there are about three thousand entries in the trade names section, which may prove the most valuable feature of the book. There are some errors which will doubtless be eliminated in another edition.—RPI.

1.7 Organized Studies of Corrosion

1.7.1, 6.3.14

Report of the Tin Research Institute for 1951. International Tin Research and Development Council. Pamphlet (1952), 16 pp. Tin Research Institute, Fraser Road, Greenford, Middlesex, Great Britain.

Matters briefly discussed include tin-nickel alloy plating, tin-zinc plating, speculum electroplate, bearing alloys, hot-tinning and tin-plate, casting bronze bars, bronze condenser tubes, heat-treatable pewter, corrosion, and chemical analysis.—BNF.

2. TESTING

2.1 General

2.1.1

Statistics—A Useful Tool for the Examination of Corrosion Data. Charles F. Lewis. A paper presented at a meeting of South Central Region, National Association of Corrosion Engineers, New Orleans, La., October 1-3, 1952. *Corrosion,* **9,** No. 1, 38-43 (1953) Jan.

"All Empirical data are probable only."

A group of observations taken to establish the value of an empirical constant must be considered as a sample of an infinitely large population, or universe, of possible readings. By the application of appropriate statistical methods to the sample, one may arrive at certain conclusions regarding the entire universe. The purpose of this paper is to discuss some basic concepts of statistical thinking, and to offer a graphical solution to the problem of estimating universe values from the sample values.

The data are prepared and plotted on special graph paper against a probability scale. From the plot are taken the most probable value of the constant sought; and the standard deviation. This latter is the slope of the plotted line, and is the key to further prediction from the data such as the confidence limits of the estimated average; a numerical expression of the precision of the test method used; and a means of comparing this method with another as to accuracy and precision. It also furnishes the answer to the question: "In the future how many readings should I take in order to have a high assurance (say of the order of 90 to 95 percent) that my estimated average will be within plus or minus 1 percent its true value."

2.2 On Location Tests

2.2.2, 6.3.19

Exposing Test in Air of Zamak 2 Alloy. (5th Report). Kazuo Katori and Kingo Naoki. *J. Mechanical Laboratory* (Japan), **6,** No. 1, 26-30, (1952) Jan.

As to zinc base die castings, the steam test adopted in the first report is mainly used for an actual test or an acceptance inspection.

However, since this method is so different from conditions met in practical use, test pieces were exposed in air for three years and then cracking phenomena were investigated.

The results obtained are as follows:

1) There are considerable differences between the results of steam test for one hundred hours and those of an exposure test in air for three years. Also, it is found that the lower the quality of zinc metal, the larger were these differences; and the longer the time interval of exposure in air, the larger was this tendency.

2) It seems to be difficult to check the cracking phenomenon accurately by the steam test of one hundred hours.

3) In cases of varying magnesium content, there scarcely exists a difference between the steam test for one hundred hours and the exposure test in air for three years.—JSPS.

2.2.2, 8.1.2, 6.4.2, 6.3.19, 5.3.2

Atmospheric Exposure Tests of Nailed Sheet-Metal Building Materials. Theodore H. Orem. *National Bureau of Standards Building Materials and Structures Report 128.* 24 pp. 18 half-tone illustrations. 6 tables. (1952). Government Printing Office, Washington 25, D. C., Per Copy, 20¢.

To determine the resistance of nailed sheet-metal building materials to atmospheric corrosion and to point out how improper installation practices can cause serious corrosion, the NBS initiated special atmospheric exposure tests of such materials. These tests were of metallic building sheets of aluminum, aluminum alloy, aluminum-coated steel, galvanized steel, and zinc alloy exposed for two years to the atmospheres of Washington D. C. and Hampton Roads, Virginia. This report describes the tests and gives important conclusions and recommendations concerning the installation of these materials.

Premature deterioration of a material usually results from contacts with dissimilar metallic materials of construction or from proximity to non-metallic materials. It is often impractical to avoid using materials that may accelerate corrosion of one of two materials when they are brought into intimate contact. It is possible, however, to insulate the materials from each other by means of paints, mastics, waterproof papers, felts, etc., to minimize corrosion.

While it is not yet possible to establish the relative resistance to corrosion of the different materials because of the short duration of the tests, the corrosion of some of the materials that has already taken place because of improper installation warrants reporting on this phase of the project now.

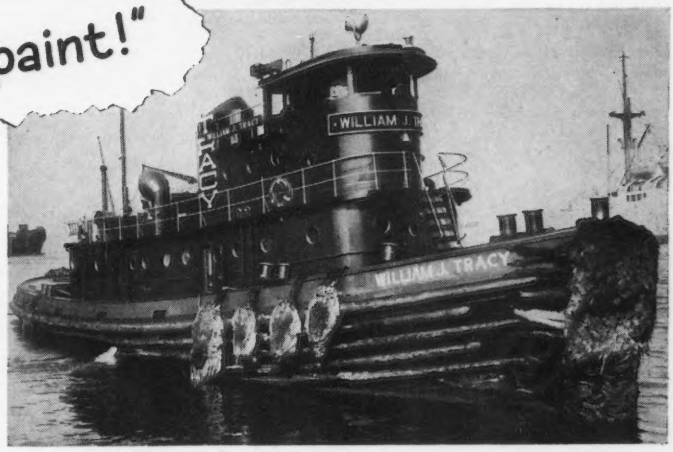
2.2.6, 7.2, 4.5.2

British Study Corrosion of Steel Iron Pipe. *Iron Age,* **169,** No. 8, 97, (1952) Feb. 21.

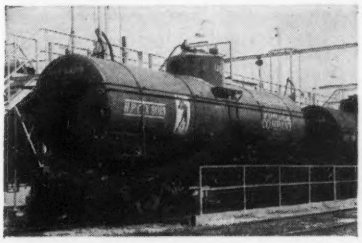
Results of corrosion tests on steel

Parlon Stays On!

"A really fine paint!"



The "William J. Tracy," flagship of the Tracy Towing Company, has all-steel decks and composition floors protected against salt water and condensation with Perry-Austen Parlon-based marine paint. Tracy Towing Company and M & J Tracy, Inc. use a variety of finishes on their tugs and other vessels, but say that there is none to surpass Parlon for these particular jobs.



Parlon-based coating by Rexton Finishes, Inc. protects rosin-size tank car from alkali spillage—has excellent durability and washability. Parlon provides long-term protection for acid tank cars, cement cars, trucks and trailers used in industrial environments.

"A really *fine* paint", says Wm. J. Lane—superintendent of barge maintenance for M & J Tracy, Inc.—about Perry-Austen Parlon-based paint. Used on steel coamings of 60 coal barges, it stands up longer against the sulfur in coal . . . the sulfuric acid formed when coal and salt spray meet . . . and accidental blows from loading buckets. And Parlon's rapid dry saves many valuable hours in drydock when barges are reconditioned annually.

For trains or trucks, for lighters or liners, equipment that moves is kept *on the move* longer when protected with paints made from Hercules Parlon (chlorinated rubber). Dozens of case histories, such as these, prove it.

Parlon is a "really *fine* paint" in every way. Finishes withstand unusual exposure to corrosion much longer than most other maintenance paints. They are easily applied, and they stick with equal tenacity to metal, concrete, macadam, wood, and various composition surfacings. And they dry almost as fast as lacquer.

Wherever corrosion is a problem, on land or on water, Parlon gives better service at lower long-term costs. See your paint supplier for details on Parlon-based paints, or write:

Cellulose Products Dept., **HERCULES POWDER COMPANY** INCORPORATED *999 Market St., Wilmington 99, Del.*

Parlon® **CHLORINATED RUBBER PAINTS**

AVAILABLE FROM 400 PAINT MANUFACTURERS UNDER THEIR OWN BRAND NAMES

CR53-2

51a

and cast iron pipe come from a series of British research projects on corrosion and the part cathodic protection plays in preventing corrosion of buried metals. Studies of bare and coated steel and cast iron buried in soils, including salt marsh, clay and cinders show that differences in soil are more important than differences in pipe material. Tables.—INCO.

2.3 Laboratory Methods and Tests

2.3.2

Research on Salt-Spray Corrosion Tests; Characteristics of the Fog. (In Italian). G. BIANCHI AND A. MORA. *Metallurgia Italiana*, **44**, 9-13 (1952) Jan.; *Electroplating*, **5**, No. 5, 163 (1952) May.

Experiments on the operation of the salt-spray chamber for corrosion tests were carried out by means of sedimentation tests, using a new solarized photographic-plate method. Dimensions of the fog particles were also determined. Apparatus is diagrammed; results are charted.—BTR.

2.3.2

A Critical Look at Salt Spray Tests. F. L. LAQUE, Inco., *Materials & Methods*, **35**, Nos. 2&3, 77-81 +, 77-81 + (1952) Feb.-Mar.

Although accepted as a means for measuring the resistance of materials and finishes to corrosive environment, salt spray tests are controversial and considered unreliable and misleading by many engineers. Tests vs. actual performance are discussed. Different materials respond differently to variations in severity of exposure not only in different materials such as zinc and steel, but also in minor variations of same kind such as different compositions of steel. Corrosion of zinc and steel in salt spray boxes and in natural atmospheres is tabulated. The test is deficient in measuring the merits of zinc and cadmium coatings on steel and in comparing nickel, and nickel and copper as a foundation for chromium plating on steel in automobile bumpers. The damaging effects of Monel on aluminum as indicated by a salt spray box are greater than those observed under natural conditions, of exposure. Salt spray tests of stainless steels are of little value. Basis of comparison of nickel-copper steel to marine atmosphere is tabulated. Tables, photographs, 11 references.—INCO.

Using TK-43
Anti-Corrosion Lining
is like getting
twice the pipe
for your money!
This extra-thick, rubber-like tough plastic lining defeats both corrosion and abrasion — makes pipe last longer. Applied by Tube-Kote experts to your new or used pipe, TK-43 gives you the protection of plastic combined with the strength of steel. TK-43 is a polyvinyl chloride plastic, centrifugally cast in one flawless operation.
Now! Your pipe joint corrosion problem is whipped: this cross-section photo shows how a joint or coupling can be machined, coated with TK-43, and threaded for a fully-protected perfect seal of all surfaces, even the ends!
You get top to bottom protection in disposal wells, your flow lines last longer, and your production tubing needs less attention when coated with tough TK-43. Mail the coupon below for full details today.
TUBE-KOTE
First Name In Corrosion Resistance
TUBE-KOTE
T.M. Reg.
Tube-Kote, Inc.
P. O. Box 20037, Houston 25, Texas.
Please send me full details on your TK-43.
Name
Firm
Street
City State
SEND THIS COUPON TODAY FOR FULL ENGINEERING DATA ON TK-43

2.3.2, 5.3.2

Rapid Corrosion Testing of Chromium/Nickel Electrodeposits. (In German). H. HEFELE. *Metalloberflache*, Ausgabe B, **4**, No. 2, B17-B24 (1952) Feb.

Survey atmospheric corrosion phenomena (porosity and blisters, cracking, peeling) and rapid corrosion tests (salt-spray, damp atmosphere, coating thickness measurements), dealing in some detail with porosity tests (ferroxyl and cupric sulfate) and the hydrochloric acid spray test.—BNF.

2.3.4, 5.3.2, 3.7.4

The Rate of Pickling Test for Tin-Plate Steels and Its Metallurgical Significance. E. L. KOEHLER, Ill. Inst. Tech. Paper before ASM, Mid-Winter Mtg., Pittsburgh, Jan. 31-Feb. 1, 1952. *ASM Preprint No. 7W*, 15 pp. (1952).

"Pickle Lag," rate of corrosion of untinned areas in tin-plate steels, determined by loss in weight of determination of hydrogen evolved by corrosion in 6N HCl at 90° C., is due to grain boundary oxides in the surface layers of the steel developed during box annealing by an atmosphere oxidizing to grain boundaries but not to ferrite. The corroding potential of the specimen in hydrochloric acid, measured against a reference electrode, may be used as a rapid unambiguous test; grain boundary oxides in the untinned steel can be identified microscopically. Graphs, tables and photomicrographs are included.—INCO.

2.3.4, 7.1, 2.4.2

Diesel-Oil Ashes—Tell This Inside Story. RAY MCBRIAN. *Power*, **96**, 112-113 (1952) April.

Discusses routine spectrographic analysis of the above in diesel-engine lubrication and service performance on the Denver & Rio Grande R. R. Co. Helps avoid serious failures due to wear, corrosion, crankcase explosions, engine-deposit buildups, material failures, and others. Spectrograms, photographs, and table.—BTR.

2.3.5, 2.4.2

Rotogenerative Detection of Corrosion. J. B. MCANDREW, W. H. COLNER AND H. T. FRANCIS. *Chemical Engineering*, **59**, No. 2, 305-306 (1952) Feb.

The new method can be used with electrolytes varying widely in conductivity and is applicable to systems whose local cells have rather small physical dimensions. The principal advantage over the other methods is that corrosion currents can be detected even when the precise location of anodic and cathodic

areas is not known. The new method is based on the fact that it is possible to separate the small potential drop produced by the corrosion current from the potential of the specimen as a whole. This is accomplished through the use of a rotating cylindrical specimen, scanned by a fixed reference electrode located close to the surface of the corroding metal. The technique in effect, generates an alternating current signal which is a reproduction of the potential gradients set up in the corrosion medium by the local-action currents—hence the name "rotogenerative." The different current potential of the specimen as a whole is readily blocked by a series capacitance, permitting amplification of the alternating current component to the desired level.—ALL.

2.3.5, 3.2.2, 6.4.1, 3.5.8

Electrochemical Tests for Estimating the Sensitivity to Intergranular Corrosion of Light Alloys. Application to the Study of the Mechanism of Stress Corrosion. (In French). P. A. JACQUET. *Recherche aeronautique* No. 25, 55-70 **1952.**

Effect of heat treatment in rendering alloys e.g., aluminum-7% magnesium and aluminum-zinc-magnesium susceptible to intercrystalline attack and to corrosion under stress. A method of anodic attack in normal sodium chloride is described and a theory is developed involving acceleration of attack by the formation of hydrochloric acid by hydrolysis. Tensile stresses enlarge the cracks, and prevent polarisation and remove the alumina formed, both of which would otherwise retard attack.—BNF.

2.3.5, 3.6.6, 6.4.2

A Study on Corrosion and Its Protection of Aluminum Alloys in Contact with Dissimilar Metals. MASAO KATO AND YASUJI NAKAMURA. *Light Metals* (Japan), No. 2, 22-27, **1952,** Feb.

The authors dealt with the corrosion behavior of aluminum alloys in contact with mild steel or brass and methods of its protection. In the first place, regarding various kind of aluminum alloys—2S, 3S, A51S, 52S, 56S, ND—and other metals, the potentials relative to a platinum pole in an aqueous solution containing 5.85% sodium chloride and 0.3% hydrogen peroxide were measured. Also in regard to 2S treated by means of various kinds of surface-preparation processes anodizing, MVB, BV, phosphoric acid-alcohol and etc. A similar measurement was carried out. The protecting effects of the insertion of zinc chromate paste, zinc sheet or cadmium sheet between aluminum alloy plate and steel or brass plate were measured, based on the drop of tensile strength and elongation after immersion for a month in the previous solution. Insertion of zinc sheet gave the best results. But any of them was better than direct contact.—JSPS.

2.3.5, 5.2.1

Low-Energy Measurement Problems in Cathodic Protection. H. N. HAYWARD AND R. M. WAINWRIGHT. *Electrical Engineering,* **71,** 276-278 (1952) Mar. (To be published in *AIEE Transactions,* **71** (1952).

Some elementary methods of obtaining metal-to-soil potential measurements are analyzed for the purpose of developing rugged yet sufficiently accurate field measuring equipment. These potentials often must be known for cathodic-protection work.—BTR.

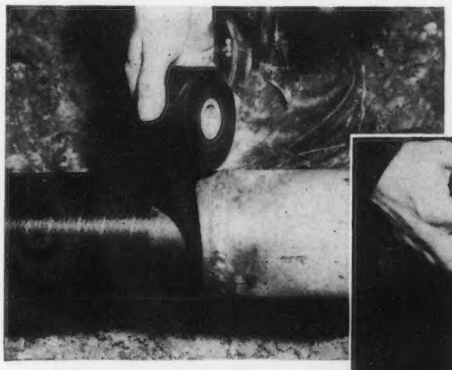
DRESSERTAPE ... the name that means

QUALITY PROTECTION

... against corrosion

Gas men for over 50 years have known that any product bearing the Dresser name really does the job for which it is made. Before recommending Dressertape to you, *we* made sure it would work—give you the lasting protection you need. Now, we ask you to try it, with the same confidence you have in other Dresser products.

Dressertape can save plenty of expensive man-hours and cut your over-all costs on every job where pipe protection is required—because it's faster, simpler, more effective.



Welded joint is quickly and permanently protected by Dressertape without special surface preparation.

Complete, uniform coverage of irregular joints and fittings is easy with Dressertape. No gaps, voids or holidays.

LOOK AT THESE OUTSTANDING DRESSERTAPE FEATURES!

- Easy, clean to apply—sticks at a touch, no heating equipment required.
- Safe to use—no burns, no fumes.
- Conforms to irregular surfaces—especially over fittings on service lines.
- Immediate backfill—no waiting.
- Exceptional electrical properties—dielectric strength: 10,000 volts; insulation resistance: 100,000 megohms.
- Lasting protection against water, oil and soil chemicals—equal to or exceeding yard or mill-wrapped pipe.

a Dressertape is a trade-mark of Dresser Manufacturing Division

DRESSER® MANUFACTURING DIVISION
Bradford, Penna.
(One of the Dresser Industries)
Warehouses: Houston, Texas and South San Francisco, California

Gentlemen: ☐ Please send detailed information and literature about Dressertape.

☐ Please have your sales engineer call with Dressertape samples.

NAME _____ TITLE _____

COMPANY _____

STREET _____

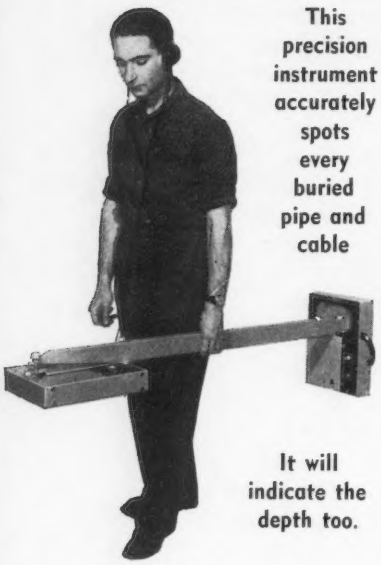
CITY _____ ZONE NO. _____ STATE _____

53a

WILKINSON LINE LOCATOR

DESIGNED RIGHT

BUILT RIGHT



This precision instrument accurately spots every buried pipe and cable

It will indicate the depth too.

This substantial carrying case is supplied.

The WILKINSON LINE LOCATOR provides low cost insurance against trouble.

Its dependability is recognized by leading utilities everywhere.

WILKINSON PRODUCTS COMPANY

3987 Chevy Chase Drive

PASADENA 3, CALIFORNIA

Tel. SYlvan 0-4314

54a

2.3.6

A New Method for Surface Flaw Detection. *Industry & Welding,* **25,** 79-80 (1952) April.

The Faxfilm process in which an exact reverse replica of a test surface is quickly made in clear plastic. Projection of this replica in a micro-projector provides a magnified representation of the surface, with marked three-dimensional effect.—MR.

2.4 Instrumentation

2.4.2

A Magnetic Thickness Gauge of New Design. E. G. HARRISON. *J. Sci. Instruments,* **29,** No. 3, 89-91 (1952) Mar.

The instrument employs a movable permanent magnet to produce the balancing force; the same magnet also serves to energize the soft iron armature. Accuracy compares favorably with that of other instruments. Modifications whereby the range may be extended in both directions.—MR.

2.4.3

Testing by Non-Destructive Methods. ROLT HAMMOND. *Overseas Engineer,* **25,** 274-276, 322-324 (1952) Mar., Apr.

Recently developed practices. Importance of the electric resistance strain gage. Developments in radiographic applications in shipbuilding and other spheres, place of radioisotopes, and need for systematic procedure in radiographic testing.—MR.

2.4.3

The Belgian Method of Ultrasonic Testing of Materials. (In French.) G. A. HOMES, Y. OTS, AND E. SYMON. *Metaux; Corrosion-Industries,* **27,** 24-33 (1952) Jan.

Describes above method and apparatus used. Application, particularly for the detection of lamination, is indicated; typical examples are cited. The value of the method is outlined. Schematic diagrams and photographs illustrate the article.—BTR.

2.4.3

Recording Device Checks Quality of Automatic Welds. GEORGE A. HATFIELD. *Industry and Welding,* **25,** 86-88 (1952) April.

Device is connected across the electrode and work to record voltage pattern of a weld. To correlate the pattern on the chart with the welded part, both the part and its chart pattern are numbered, and if the chart curve deviates from normal, the part is x-rayed.—MR.

2.4.3

Ultrasonic Equipment Testing in the Petroleum Industry. DWIGHT J. EVANS. *Oil and Gas Journal,* **50,** 70-72-82, 84 (1952) Feb. 4.

Ultrasonic instruments used both for detection of hidden flaws and measurement of metal thickness, as exemplified by the "Reflectoscope" and the "Audigage."—MR.

2.4.3

Measurement of Luster as a Method of Evaluating Metallic Surfaces. (In German.) JOHN ELZE AND H. GRUSS. *Metalloberflache,* ser. A, **6,** A17-A23 (1952) Feb.

Instrument measures strictly directed reflection, reflection within a selected range of dispersion angle and astigmatism of dispersion.—Diagrams, photographs, graphs, photomicrographs, and tables.—MR.

2.4.3, 2.3.9

A New Ultrasonic Probing Apparatus, Its Practical Utilization. (In French.) J. KRAUTKRAMER AND H. KRAUTKRAMER. *Metaux; Corrosion-Industries,* **27,** 89-94 (1952) Feb.

Apparatus is based on the impulse and reflection method. In the case of defects near the surface, minimum depth of defect necessary for a direct indication is lowered considerably. Even at 8 mm. depth, the echo is separated from the impulse. Measuring with precision the width of surfaces is possible on sheets 3 mm. wide.—MR.

3. CHARACTERISTIC CORROSION PHENOMENA

3.2 Forms

3.2.2

Hydrogen Causes Embrittlement of Forged Compressor Blades. A. E. DURKIN. (General Electric Co.) *Steel,* **130,** No. 12, 76-78 (1952) Mar. 24.

Hydrogen present in blades is the product of electrolytic surface corrosion, the result of a reaction between the moisture in the atmosphere and dirt or other foreign matter on the blades. Article discusses the high internal pressures built up when molecular hydrogen is formed, and the determination of the amount of hydrogen present in field blades. Painting decreases susceptibility to embrittlement as it prevents corrosion on the surface of the strip. Photographs are included.—INCO.

3.2.2, 1.7.1, 2.2.3, 8.4.3, 6.2.4

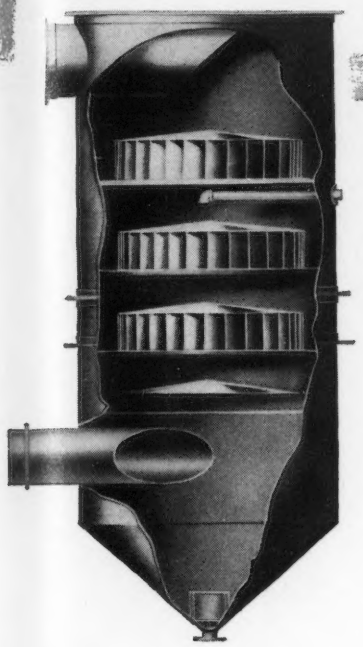
Field Experience With Cracking of High Strength Steels in Sour Gas and Oil Wells. A Report of Technical Practices Committee 1-G. A report presented at the Eighth Annual Conference and Exhibition, National Association of Corrosion Engineers, Galveston, Texas, March 10-14, 1952 by R. S. TRESEDER, Chairman, NACE Technical Practices Committee 1-G on Sulfide Stress Corrosion. *Corrosion,* **8,** No. 10, 351-354 (1952) Oct.

This is a report by Committee TP-1G on accumulated field experience of several companies with corrosion cracking of oil well tubular goods and wellhead fittings in sour gas and oil wells. This cracking effect has been associated principally with use of high-strength steels in sour gas-condensate wells. Although relatively few failures have been experienced, the problem is a serious one in view of the high pressures involved and the rapid, unpredictable nature of the corrosive attack. Descriptions of failed tubing, casing, and wellhead fittings are given together with data obtained from stressed specimens of various alloys placed in flowlines of wells in several fields. These data show that sulfide corrosion cracking is associated with alloys of high strength, i.e., high hardness, and that the effects may vary among individual wells owing to differing producing conditions and fluid compositions. Possible remedial measures are discussed.

3.2.2, 3.5.8, 6.2.4

Stress Corrosion Cracking of Steel Under Sulfide Conditions. C. N. BOWERS, W. J. MCGUIRE AND A. E. WIEHE. A paper presented at the Eighth Annual Conference, National Association of Corro-

Two Years without Maintenance



A dust collector of this design was constructed entirely from 14-gage HASTELLOY *alloy B sheet to resist severe corrosive conditions.*

Handling...

Hydrochloric Acid Vapors
Sulphuric Acid Mist
Nitrous Oxide
Chlorobenzol
Toluol
Aerated Benzol
Aromatic Amides

Three HASTELLOY alloy B dust collectors have just completed 2 years' steady service handling these corrosive chemicals. They are used in a large chemical plant to wash reaction gases and to reclaim many valuable chemicals.

HASTELLOY alloy B has excellent resistance to hydrochloric acid in all concentrations, even to the boiling points. It also has good resistance to sulphuric acid and many other chemicals. The alloy can be fabricated into practically any type of chemical equipment.

For information on the resistance HASTELLOY alloy B has shown to many corrosive media and on fabrication procedures, write for a copy of "HASTELLOY High-Strength, Nickel-Base, Corrosion-Resistant Alloys."

HAYNES TRADE-MARK *alloys*

Haynes Stellite Company
A Division of
Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago — Cleveland — Detroit — Houston
Los Angeles — New York — San Francisco — Tulsa

"Haynes" and "Hastelloy" are trade-marks of Union Carbide and Carbon Corporation.

55a

sión Engineers, Galveston, Texas, Mar. 10-14, 1952. *Corrosion,* **8,** No. 10, 333-341 (1952) Oct.

Rapid failures of tubing in a sour condensate well led to an extensive laboratory and field investigation to determine the cause and remedy for these failures. Apparently, failures occur because of stress corrosion cracking. Embrittlement resulting from exposure to moist hydrogen sulfide is not considered a primary cause of failures, but it may have been an important contributing factor.

The exact mechanism of failure has not yet been definitely established. The failure process can be prevented or appreciably retarded by suitable heat treatment and/or change in steel composition. Susceptibility to failure of most steels is increased by plastic deformation.

In most instances failures were more rapid in field tests, which indicated that the field operating conditions involving pressure, flow, and formation water were more severe than the laboratory test conditions selected. In both tests there was little advantage for alloy steels over plain carbon steels. It was apparent, that for most steels, limitations on the maximum permissible mechanical properties are just as important as minimum limits.

3.2.2, 6.2.4, 2.3.4

Cracking of High Strength Steels in Hydrogen Sulfide Solutions. J. P. FRASER AND R. S. TRESEDER. Paper presented at the Eighth Annual Conference, National Association of Corrosion Engineers, Galveston, Texas, March 10-14, 1952. *Corrosion,* **8,** No. 10, 342-350 (1952) Oct.

Laboratory data are presented relating to the spontaneous cracking and embrittlement of steel alloys under environmental and stress conditons pertinent to sour gas condensate wells. It has been shown that cracking can occur in simple aqueous hydrogen sulfide solutions and is an effect related to stress corrosion cracking. A mechanism involving stress corrosion cracking and hydrogen embrittlement is proposed to explain the cracking phenomenon. Important factors studied included composition and heat treatment of alloy type and magnitude of stress. Composition of corrosive solution (e.g., acidity, salt content), composition and pressure of gas environment, temperature and time of exposure. Of these the first three were found to be the most important. Remedial measures discussed include use of resistant alloys, heat treatment of susceptible alloys, organic and metallic coatings and inhibition. A simple laboratory procedure is presented for making a preliminary evaluation of the cracking susceptibility of a given alloy.

3.2.2, 8.4.3, 6.2.4, 3.5.8

Hydrogen Sulphide Corrosion Cracking of Steel. L. W. VOLLMER. Paper presented at the Annual Western Meeting, Canadian Institute of Mining and Metallurgy, Calgary, Alta., October, 1951. From "The Canadian Mining and Metallurgical Bulletin," February, 1952. (Transactions, Vol. LV, 89-95 [1952].) *Corrosion,* **8,** No. 10, 326-332 (1952) Oct.

Sudden blow-out of tubing after only six days of production tests of the 12,000-foot Walter Marr Well No. 1, Pincher Creek Field, Canada, caused an investigation of causes for failure. Examination of the removed 9 percent nickel steel tubing showed no obvious defects and calculations showed failures not due to excessive triaxial loading.

Investigators, after discarding embrittlement as a cause, initiated tests to determine if stress corrosion cracking was the cause, because well fluids and gases included 10 percent hydrogen sulfide and 6.3 percent carbon dioxide by volume. Specimens of 9 percent nickel steel tubing were submerged in tap water containing hydrogen sulfide and carbon dioxide in a cell at 5000 psi and 190 degrees F. All specimens failed in six days.

Numerous other tests of the tubing and other steels at varying loadings were conducted, including pre-stressed and re-heat treated but not pre-stressed samples. These tests developed the following tentative conclusions: 1) Tubing failures at the Marr well resulted from stress-corrosion cracking. 2) Susceptibility to failure in hydrogen sulfide environments is not limited to 9 percent nickel steel. Steels treated to produce Rockwell C24 to 26 may be rendered susceptible. 3) Plastic deformation greatly increases susceptibility to failure, but is not essential if protective corrosion products films are removed. 4) Embrittlement is not a primary cause of failure but may be contributory. 5) Susceptibility may be reduced by composition changes.

3.2.3, 3.5.8

Film-Rupture Mechanism of Stress Corrosion. H. L. LOGAN. *J. Research Natl. Bur. Standards,* **48,** No. 2, 99-105 (1952) Feb.

The atmospherically formed protective films were removed by abrasion in an argon atmosphere from surfaces of an aluminum alloy, two brasses, a magnesium alloy, and low-carbon and stainless steels. The resulting surfaces were 0.12 to 0.76 volt more negative with respect to a calomel electrode than surfaces prepared and measured under normal atmospheric conditions. Appreciable changes in electrochemical solution potentials of notched specimens, stressed in tension, occurred at or just above stresses at which the true stress—true strain curves deviated from the modulus lines. These changes in potential were caused by rupturing of the protective films at the roots of the notches and were of the order of 0.16 to 0.70 volt at failure, depending on the material. Stress corrosion is postulated to occur in corrosive media, at stresses sufficient to rupture the protective film, by electrolytic action between the filmed (cathodic) and film-free (anodic) areas. (Author's summary.)—ALL.

3.2.3, 4.3.2, 4.2.1, 3.4.3

Decomposition of Oxide Films on Metal Surfaces in Acid Vapors and Mechanism of Atmospheric Corrosion. (In German.) W. FEITKNECHT. *Chimia,* **6,** No. 1, 3-13 (1952) Jan. 15.

Describes experimental studies which show that corrosion is caused by impurities in the air, that corrosion occurs rapidly only above a humidity of about 70 percent, that copper is protected by the products of corrosion, and that the product of corrosion of iron is a hydroxide, while the other metals form normal and basic sulfate, or a mixture of sulfate and sulfuric acid. Tables, graphs and electrom micrographs. 34 references.—BLR.

3.2.3, 4.3.6, 2.3.7, 3.8.4

Diffusion of Sodium Chloride Through Various Paint System. W. W. KITTELBERGER AND A. C. ELM. Paper before Am. Chem. Soc., Div. of Paint, Var. and Plastics Chem., Boston Meeting, 1951. *Ind. and Eng. Chem.,* **44,** No. 2, 326-329 (1952).

A method for the determination of the instantaneous rate of diffusion of electrolyes through paint films has been developed. The method has been applied to the systematic study of the diffusion of sodium chloride through a number of paint coatings, including representative metal-protective paint systems. Results for four media pigmented with ten pigments are quoted. 5 references.—RPI.

3.3 Biological Effects

3.3.4, 4.5.2, 7.2

Microbiological Corrosion of Buried Steel Pipe. FRANK E. KULMAN. A paper presented at a meeting of Pittsburgh Section, National Association of Corrosion Engineers, March 6, 1952. *Corrosion,* **9,** No. 1, 11-18 (1953) Jan.

Early corrosion investigations in New York City were concerned with electrolysis caused by stray currents leaking from elevated and trolley lines. This problem was solved by installing insulating joints in the gas mains. Attention was then given to mitigating soil corrosion which is responsible for many of the leaks being experienced. Test data at 472 field excavations showed that the most severe corrosion usually occurred in the poorly aerated clay soils containing organic matter. Bacterial action was indicated in 81 percent of the locations of severe corrosion. This revelation prompted a detailed investigation of the bacterial influence in underground corrosion. Population counts of five types of anaerobic and aerobic bacteria were determined at corrosive locations, concurrently with measurements of moisture content, organic matter, aeration and pH of the soil and the presence of sulfide in the corrosion product. Seasonal variations in the soil moisture, aeration and population of anaerobic bacteria were found to be associated with the underground corrosion cycle. Following a discussion as to the probable mechanisms of bacterial corrosion, the need for further improvement of the soil redox probe developed in the American Gas Association investigation is indicated. This probe measures the reducng intensity of the soil and thus locates corrosion areas prior to installing the pipe.

3.4 Chemical Effects

3.4.3, 2.3.9

The Nature of Zinc Corrosion Products. P. T. GILBERT. *J. Electrochem. Soc.,* **99,** No. 1, 16-21 (1952) Jan.

A description of work carried out by the British Non-Ferrous Metals Research Association into the nature of corrosion products formed on zinc when immersed in hot or cold water and into the changes occurring when zinc hydroxide and zinc oxide were kept hot or cold in air or under water. X-ray diffraction methods were used to identify the products formed. The author concludes that zinc oxide is usually formed when zinc corrodes in hot waters, zinc hydroxide or basic zinc salts being more usual products in cold waters. He suggests that the ennoblement of zinc in hot, aerated solutions may be due to the presence of zinc oxide films with slight electronic conductivity. —ZDA.

3.4.6, 3.8.4
Mechanism of Corrosion by Oxygen. (In French.) RENE AUDUBERT. *Compt. rend.*, **234**, 1448-1450 (1952) Mar. 31.
The theory of overvoltage is applied to the corrosion of metals in the presence of oxygen, making it possible to explain the mechanism of the phenomenon.—BTR.

3.4.6, 6.3.17
On the Oxidation of Metallic Uranium. JEAN LORIERS. *Compt. rend.*, **234**, No. 1, 91-93 (1952).
Uranium oxidizes by a mechanism comparable with that of cerium. The initial oxide film, homogeneous and protective, thickens as it breaks up, so that the curve of weight of oxide/time, as recorded on a thermo-balance, changes from the parabolic form to the linear as the temperature approaches the temperature of ignition. Up to 140° C. the f.c.c. structure of UO_2 ($\alpha = 5 \cdot 46$ Å.) is found on X-ray examination. Between 140° and 240° C. the parameter decreases to 5•41 Å., and micro-examination shows that in this range two oxide films exist: an outer one containing fissures caused by contraction of the original UO_2 film and an inner, continuous one whose thickness diminishes with temperature rise until at 230° C. it is indistinguishable. Above 240° C. the orthorhombic structure of U_3O_8 appears.—MA.

3.4.6, 6.3.21
The Reaction of Cerium With Oxygen. DANIEL CUBICCIOTTI. *J. Am. Chem. Soc.*, **74**, 1200-1201 (1952) Mar. 5.
Oxidation of cerium was found to obey the parabolic law from 30 to 125° C. Above 125° C. the reaction started parabolically, but subsequently became linear. The parabolic portion became shorter as the temperature was increased. Cerium is the most rapidly oxidizing metal yet studied. Energy of activation of the parabolic reaction is the smallest yet observed.—MR.

3.5 Physical and Mechanical Effects

3.5.8, 5.8.2, 5.11
Lubricant Corrosion Is Being Licked. *Chem. Eng. News*, **30**, 1098 (1952) Mar. 17.
Tells how molybdenum disulfide can be used to prevent fretting corrosion of closely fitted machine parts. Design factors are considered as a means of eliminating crevice corrosion in engines.—BTR.

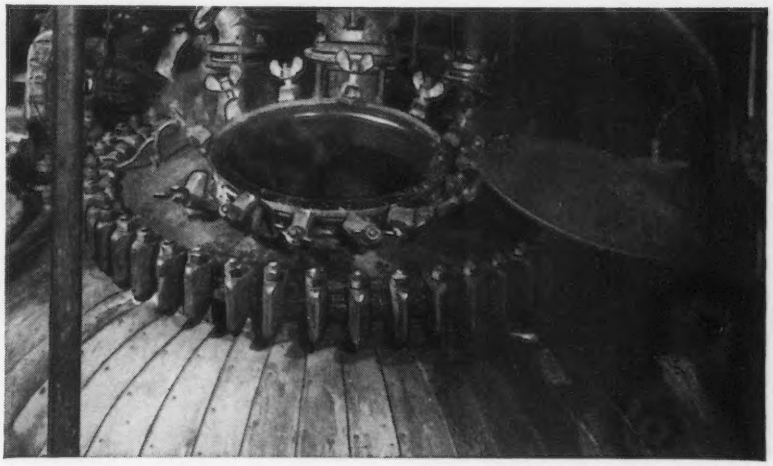
3.5.8, 7.1, 5.11
Fretting Corrosion, II, *Allen Eng. Rev.*, **1952**, 2-5, Jan.
Deals with preventive measures and gives examples from practice concerning case-hardening of one component, increasing compressive load to a value at which all sliding motion is eliminated and improved lubrication arrangements. The second method applied to combat fretting corrosion in joint between turbine rotor shaft (mild steel) and nickel-chromium-molybdenum steel pinion.—INCO.

3.5.9, 4.7, 3.6.10
The Cathodic Corrosion of Iron and the Anodic Formation of Crystallized Ferrite by Electrolysis of Molten Sodium Hydroxide. (In French.) M. DODERO. *J. chim. phys.*, **49**, C210-C213 (1952) Feb.
Electrolysis of molten sodium hydrox-

DOW

SARAN RUBBER LINED KETTLE RESISTS HOT HYDROCHLORIC ACID

Another example of how SARAN RUBBER TANK LINING helps cut cost of handling, storing or transporting corrosives



Here's a typical saran rubber tank lining application. This 2,000 gallon kettle, with baffle and agitator, handles hydrochloric acid and crystal slurry at 50° C. Lined with saran rubber over a year and a half ago, the kettle has given efficient and constant service since.

Saran rubber's high degree of chemical and abrasive resistance makes it the ideal lining for tank cars, storage tanks, tank trailers, processing tanks and other equipment handling corrosive acids, solvents, and other chemicals.

Saran rubber lining can be applied easily and economically by experienced saran rubber applicators located strategically throughout the country. We will be glad to advise you as to where and how saran rubber lining can be applied to your best advantage. Get in touch with your nearest SARAN LINED PIPE COMPANY office or write direct to The Saran Lined Pipe Company, 2415 Burdette Avenue, Ferndale, Michigan. Offices in New York • Boston • Pittsburgh • Tulsa • Philadelphia • Chicago • Portland • Indianapolis • San Francisco • Houston • Denver • Los Angeles • Seattle • Cleveland • Charleston, S. C. • Toronto • Montreal.

RELATED PRODUCTS

Saran rubber molded parts—stoppers, diaphragms, various-sized moldings for valves, instruments, etc.

Saran lined steel pipe—corrosion-resistant pipe that gives long-term operation with minimum maintenance costs.

Saran Lined Pipe Company
2415 Burdette Avenue, Ferndale, Michigan

Please send me your catalog on Saran Rubber Tank Lining and Saran Rubber Molding Stocks.

Name_____

Title_____

Company_____

Address_____

City_____ State_____

you can depend on DOW PLASTICS

DOW

57a

ide between 500 and 750° C, using iron electrodes under particular conditions of current density and distance between electrodes. Cathodic corrosion and anodic formation of crystallized sodium ferrite were observed. Graphs and diagrams.—MR.

5. PREVENTIVE MEASURES

5.2 Cathodic Protection

5.2.1, 4.5.3, 2.2.6, 2.4.2

Soil Resistivity Measurements for Corrosion Control. F. O. WATERS. Southern California Gas Co., Los Angeles, Cal. A paper presented at a meeting of Western Region, Nat. Assoc. Corrosion Eng., Los Angeles, Cal., June 20, 1951. *Corrosion*, **8**, No. 12, 407-409 (1952) Dec.

Results of experiments to determine most practical soil survey procedure and best equipment are given. Correlation between soil resistivity and corrosion is divided into five classes. Soil corrosivity maps of the area served by Southern California Gas Company were prepared. Details of several types of equipment for determining soil resistivity are given with good and bad points of each. Rules for interpretations of results are listed and the use of soil resistivity determinations indicative to types of coating are outlined.

5.2.1, 8.4.3

Cathodic Protection in Refineries. *Chem. Age*, **66**, 165-167 (1952) Jan. 26.

Two fundamental and mutually complementary approaches to cathodic protection in refineries are use of D.C. electricity supplied from a power source, which is not advantageous for protecting large metal surfaces (e.g. bottoms of large tanks) where conditions are particularly corrosive, and use of an expandable anode to protect relatively small surfaces (e.g. tube sheets in heat exchanges, short pipelines). Type applications of these methods are described and methods of estimation of current requirements discussed.

5.2.2, 5.2.3, 8.4.3

Applications of Cathodic Protection to Control Refinery Corrosion. V. W. HATCHETT. *Oil Gas J.*, **50**, No. 45, 256, 258-259, 261-262 (1952) Mar. 17.

Practical suggestions for controlling corrosion of refinery equipment by use of sacrificial anodes and induced current anodes. Specific case histories illustrating both of these methods are given. The life of the anodes and their effective radius is substantially increased with the use of paint and/or inhibitors. Magnesium anodes are used successfully in protecting underground oil and water lines, box coolers, shell-and-tube coolers, water pumps, trays and water tanks. Illustrations and 10 references are included.—INCO.

5.2.2, 5.2.3, 8.9.5, 4.6.11, 4.6.7

Prevention of Corrosion of Ships in Sea Water by Means of Cathodic Protection. K. N. BARNARD. *Research*, **5**, Nos. 3 & 4, 117-125; 176-180 (1952) Mar., April.

Discusses the investigations at the Naval Research Establishment on the corrosion and its prevention on underwater hulls of ships. Magnesium anodes as a means of protection for ships, and the advantages and disadvantages of graphite anodes are listed. Zn is not a satisfactory material to use as a galvanic anode in the protection of steel ships. A practical demonstration of the cathodic protection of an inactive ship is cited. The protection of inactive ships in fresh water is not as cheap or as easy as ships in sea water.—INCO.

5.2.2, 7.4.2, 4.6.6

Cathodic Protection of Glass-Lined Water Heaters. *Engineers' Digest*, **13**, No. 4, 101 (1952) Apr.

In the course of an investigation of methods for protecting pipe lines from soil corrosion, it was discovered that the cathodic protection of glass-coated pipe lines was more effective than cathodic protection of bare pipe or of pipe coated with organic materials. A particularly recent example is the application of this principle to glass-lined water heaters. A recent report describes the results obtained with both glass-lined and galvanized gas-fired water heaters, in which magnesium anodes were installed for corrosion protection.—INCO.

5.2.3, 3.6.9, 8.2.1

An Improved Electrolysis Switch. VERNON B. PIKE. Bell Telephone Laboratories, Inc., Murray Hill, New Jersey. A paper presented at the Eighth Annual Conference, National Association of Corrosion Engineers, Galveston, Texas, March 10-14, 1952. *Corrosion*, **8**, No. 9, 311-313, Discussion 322 (1952) Sept.

An improved electrolysis switch has been placed in use in the Bell System for mitigation of electrolysis of cables by stray currents. It consists of three relays operating in sequence, namely control, intermediate and drain relays. It automatically closes a drainage bond between a lead-covered underground cable and a power return ground when stray current is picked up by the cable to such an extent as to make some of the sheath positive with respect to its environment. It also opens the bond when the drainage current falls to zero and drainage is no longer required. Two sizes are used capable of draining 200 amperes and 400 amperes, respectively.

Its action is very fast, only .015 second elapsing from the time the control circuit releases until opening of the drainage bond. Separate adjustments are available for setting the voltage at which the switch closes and opens the drainage bond.

A capacitive voltage booster enables switch operation over longer battery power supply wires than is possible if the booster is not used. A power supply unit consisting of a stepdown transformer and selenium rectifier is also available to operate the switch with power drawn from an AC power source if the switch must be installed beyond reach of the battery power.

A sealed steel housing enables the switch to withstand submersion and permits installation in very damp locations.

5.2.3, 7.7, 7.2, 4.5.2

Cathodic Protection of Steam-Electric Generating Stations. J. H. COLLINS AND E. H. THALMANN. (Ebasco Service Inc., New York, New York). A paper presented at the Seventh Annual Conference National Association of Corrosion Engineers, New York, N. Y., March 13-16, 1951. *Corrosion*, **8**, No. 9, 314-320 (1952) Sept.

Corrosion of underground structures, applications of cathodic protection and testing procedures are discussed. Piping, cable sheaths and other structures at electric generating stations are solidly connected (for safety of personnel during power fault conditions and for reduction of the station ground resistance) to the station grounding system, which generally is an extensive grid of heavy bare copper cable and ground rods. The resulting galvanic cell is an important factor in corrosion, particularly when the structures are in low resistivity soil. Current requirements for cathodic protection range from 50 amperes to several hundred-amperes, supplied from rectifiers and graphite anode-coke breeze ground beds. Choice of ground bed locations is restricted by the need of avoiding proximity to underground structures. The station grounding system generally is connected to transmission line shield wires or counterpoises, or to transmission cable sheaths which take a part of the cathodic protection current. Precaucaution to avoid shock hazards during power faults is necessary in isolating incoming pipe lines. Pronounced shielding effects result from large pipe lines, multiple cable runs and reinforcing steel in concrete mats. Testing procedure includes checking continuity of the grounding system and tests of current distribution, potential changes and polarization effects to determine protection. Circulating water intake screens, spillway gates and other isolated structures require separate additional protective installations.

5.2.3, 8.3.1

Cathodic Protection from Corrosion. J. P. COLLOPY. (U.S. Dept. of the Interior). *Agr. Eng.*, **33**, No. 3, 153-154 (1952) Mar.

A discussion on cathodic protection from corrosion considers the source of current, cathodic protection for farmstead and the savings possible. Cathodic protection can be used in the farmstead for steel water lines, cast-iron sewer lines, steel culverts, steel storage tanks and steel septic tanks. After installation the cost per kilowatt hour is only to be considered since any scrap steel such as steel rails or long life C units can be used. To test the efficiency of an installation, a small polished steel plate can be welded to the steel to be protected and the appearance of any corrosion noted. Illustrations.—INCO.

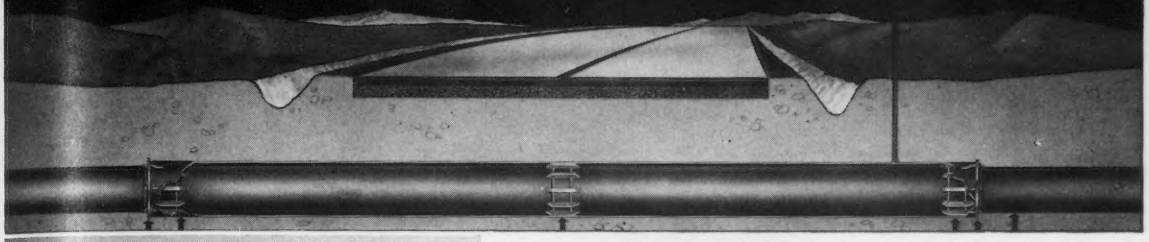
5.2.4

Optimum Protective Potential for Cathodic Protection. National Bureau of Standards Determines Optimum for Cathodic Protection. *Gas Age*, **109**, 25, 59-60 (1952), Jan. 31.

A recent study by the National Bureau of Standards Provides a scientific basis for the cathodic protection method of combating underground corrosion of iron and steel.

By eliminating uncertainties inherent in field measurements, the NBS was able to determine an optimum protective potential of —0.77 volt referred to a saturated calomel electrode. To confirm experimentally the effectiveness of a minus 0.77 volt, weighed steel electrodes were exposed to 5 soils in specially designed corrosion cells. After 2 days without protective current, the electrodes were maintained at minus 0.77 volt for 60 days. Weight loss during the test by the electrodes maintained at minus 0.77 volt was negligible compared with weight losses of control electrodes that received no current. Electrodes allowed to deviate for relatively short periods to potentials less negative than minus

A tested and proven design for efficient pipeline protection. . . . More than 18,000 crossings equipped since 1950. . . .



Williamson

CONCENTRIC-SUPPORT INSULATORS

Provide low-cost, dependable protection for right-of-way crossings . . . Simple to install with a common wrench . . . Impervious to pipe coatings . . . Support blocks center pipe in casing, spacer blocks provide clearance through casing . . . Available for all combinations of pipe and casing diameters.

TYPE "L" WmSEAL CASING BUSHINGS

Provide a water-tight seal even under the worst conditions of out-of-round casing . . . Unaffected by dirt, moisture or backfill during or after installation (no dope, adhesive or shield required) . . . Electrical insulation of pipe from casing provides economical cathodic protection.

Write for Bulletin 249-A

Easily installed with common hand tools.

Visit Us At the IPE—Booths 28-29 Oklahoma Bldg. Tulsa — May 14-23

T.D. Williamson, Inc.

P. O. BOX 4038

TULSA 9, OKLAHOMA

THE PIG WITH THE POKE CLEANS PIPE LINES

REPRESENTATIVES

CANADIAN EQUIPMENT SALES & SERVICE CO., LTD.
EDMONTON, CALGARY, TORONTO, CANADA

PHILIP H. MOORE
DURBAN, NATAL, SOUTH AFRICIA

LANGLEY Y CIA.
BUENOS AIRES, ARGENTINA

KERR ENGINEERING SALES CO.
PIGS & TAPPING MACHINES
PITTSBURGH 22, PENNSYLVANIA

H. E. DAVIS
LOS ANGELES, CALIF.

STUART STEEL PROTECTION CORP.
BUSHINGS & INSULATORS
KENILWORTH, N. J.

BEN W. BRUNDAGE COMPANY
OAKLAND 11, CALIFORNIA

JAMES S. KONE CO.
AMARILLO, TEXAS

HAMMOND IRON WORKS
KEYES TANK DIVISION
CASPER, WYOMING
PROVO, UTAH

TOD PASDRAL
HOUSTON 5, TEXAS

59a

0.77 volt lost appreciable weight, but electrodes maintained at more negative potentials (minus 1.0 volt) showed no appreciably greater reduction in weight loss.

The current required to maintain a minus 0.77 volt protective potential is not uniform. It was possible to estimate the minimum protective current initially required for cathodic protection in a particular soil by preliminary measurements.

Prior to disassembling the corrosion cells, the protected electrodes were left without protective current for about 15 hours, after which a curve relating potential to applied current was again obtained. This time the change-in slope typical of corroding was no longer evident. This was taken as a further indication of the effectiveness of the protection against corrosion furnished by the minus 0.77 volt protective potential.

5.2.4, 3.4.6

The Role of Oxygen In Corrosion and Cathodic Protection. ROY V. COMEAUX. A paper presented at the Eighth Annual Conference National Association of Corrosion Engineers, Galveston, Texas, March 10-14, 1952, based on a paper presented at a meeting of South Central Region NACE at Corpus Christi, Texas, October 17-19, 1951 *Corrosion* **8,** No. 9, 395-309 (1952) Sept.

The oxidation of iron is accompanied by the simultaneous reduction of some other material. In the case of buried steel, above pH 4.5 the reduced substance is oxygen. The two electrons furnished by the corrosion of an iron atom reduce one-half molecule of oxygen to hydroxyl ion. Corrosion ceases if access of oxygen to all points of the surface is eliminated.

Complete cathodic protection is achieved when electrons are supplied at the steel surface at the same rate oxygen molecules diffuse to the surface. Current drainage of 1 ma./sq. ft. is equivalent to 6.24×10^{15} electrons/sq.ft./sec.; this amount reduces 1.56×10^{15} molecules of oxygen, or the amount of oxygen in 318 monolayers of water. This establishes the role of diffusion of oxygen in cathodic protection; any factor which affects diffusion of oxygen to the steel surface will affect the current requirements for cathodic protection. The Baytown Refinery cathodic protection system drains 12,000 amperes, an amount just sufficient to reduce one gram of oxygen per second reaching the buried surface area of about 10,000 sq. ft. It is roughly estimated that the average thickness of the soil diffusion layer in the Baytown Refinery is equivalent to one inch of quiescent water.

The influence of the thickness of the diffusion layer on the current density requirements for complete cathodic protection can be developed from Fick's Law of Diffusion in the simple form:

$$I_d \cong \frac{2.15}{\delta} \text{ma./sq.ft. where } \delta \text{ is in centimeters.}$$

5.2.4, 5.11, 2.3.5

Potential Measurements in Cathodic Protection Designs. ROBERT P. HOWELL. Paper presented at a meeting of Western Region, NACE, Los Angeles, Cal., November 9, 1951. *Corrosion,* **8,** No. 9, 300-304 (1952) Sept.

Criteria for determining effective cathodic protection are listed as: 1) Current density. Useful when current density required for protection is known and the design of the structure lends itself to reasonably accurate determination of current pickup. 2) Potential change. The author believes a potential change of 0.3 volt is adequate but suspects it results in over-protection. Polarization effects may obscure significance of measurements. 3) Current-potential curves. Elaborate equipment is required and the method is time consuming. 4) Copper-Sulfate Potential. The accepted criterion of 0.85 volt loses some of its validity in highly aerated soils.

Methods, instruments, techniques and examples of potential measurements are given. Multiple-rectifier systems, pipe lines in salt water, steel structures in salt water, and oil and gas well casings are considered.

5.3 Metallic Coatings

5.3.2, 2.3.2, 2.2.2

Protecting Steel in Aluminum. *Foundry Trade J.* (England), **92,** No. 1850, 178, (1952) Feb. 14.

The results of a series of tests made at the Fulmer Research Institute on tin-zinc alloy coating for the protection of steel bolts used in aluminum structures are given in "Tin and its Uses," December 1951. The protective coatings used were: Sherardized, zinc-plate, black oxide finish, cadmium, Parkerized, tin-zinc alloy coated. Unprotected steel and solid brass were included for comparison. Three bolts of each type were fixed into a piece of aluminum plate and one set of the specimens was exposed for 26 weeks to each of the following corroding conditions: 1) 3 per cent sodium chloride spray, daily, 2) humid sulfur dioxide atmosphere, 3) marine atmosphere at Hayling Island, 4) industrial atmosphere at Sheffield. The salt spray test proved more severe than the sulfur dioxide atmosphere. In all cases the tin-zinc alloy coatings not only protected the steel bolts but produced a minimum amount of corrosion of the aluminum plates. Zinc coatings proved second-best; although a good deal of corrosion was formed on the zinc, the steel was not attacked and corrosion of the aluminum was slight. None of the other coatings gave full protection throughout the tests. —ALL.

5.3.2, 2.3.2, 2.3.7

Corrosion Resistance of Copper-Nickel-Chromium Plated Zinc-Aluminum-and Magnesium-Base Diecastings. M. R. CALDWELL, L. B. SPERRY, L. M. MORSE AND H. K. DELONG. *Plating,* **39,** No. 2, 142-148, 159-163 (1952) Feb.

Objectives of this project were to determine how copper-nickel-chromium plated zinc-, aluminum-, and magnesium-alloy diecastings compared as to rate and type of corrosion when exposed to different outside atmospheres and salt spray tests; how much plate is required to furnish adequate protection for each; how different alloys of aluminum compare with each other, and how Watts nickel compares with a bright nickel under these conditions. The test panels were plated and the copper and nickel thicknesses were measured microscopically and the chromium thickness by the drop test. The results of the outdoor-exposure tests, as well as of the salt-spray tests are given in table form. There appeared to be 2 major types of corrosion one acted by actually attacking and pitting the plate itself and the other type acted by corroding the base metal through pores in the plate, mainly owing to galvanic action between the plate and the base metal. In a comparison of buffed Watts nickel with bright nickel, the buffed Watts nickel was slightly better over all 3 base metals. A total plate thickness of 0.002 inch was necessary to provide adequate protection against corrosion of zinc-, aluminum-, or magnesium-base diecastings. Graphs, tables and photomicrographs are included.—INCO.

5.3.2, 3.5.9, 6.3.6, 6.2.5

Stainless Clad Copper for High Temperature Service. JOSEPH KINNEY, JR. *Product Eng.,* **23,** 129-133 (1952) Apr.

Offers a combination of the high thermals conductivity of copper with the corrosion and heat resistance of stainless steel. Data on mechanical and physical properties, workability, corrosion resistance, annealing, and welding are charted.—MR.

5.3.2, 5.3.4, 5.9.1, 4.2.5 8.9.5

Metallizing Cuts Marine Maintenance Costs. FRED M. EARLE. *Iron Age,* 169, 103-105 (1952) Jan. 31.

How aluminum and zinc sprayed on properly cleaned iron and steel and coated with vinyl sealers are effectively protecting steel fishing boats from salt-spray corrosion. Maintenance costs are lower. Entire envelopes of ships are being sprayed during construction to protect steel hull and deck plates.—MR.

5.4 Non-Metallic Coatings and Paints

5.4.1, 5.3.1

Spotlighting Finishing Progress. ALLEN G. GRAY. *Products Finishing,* **16,** 46+ (1952) Jan.

Discusses in length some recent contributions on the following topics: electrochemical and chemical coatings for aluminum; lacquers for finishing military products; mechanism of paint blistering in sea water; corrosion resistance of anodized titanium; and acid recovery in continuous strip pickling.—BLR.

5.4.2

Islanding—A Surface Characteristic of Some Porcelain Enamels. M. K. BLANCHARD AND W. A. DERINGER. *J. Am. Ceramic Soc.,* **35,** 12-15 (1952). Jan. 1.

Observations made during an investigation of a porcelain-enamel surface characteristic called "islanding" are presented. The appearance and characteristic of islanded enamel surfaces are described and possible modes of formation considered. Results of corrosion tests on islanded and non-islanded surfaces are included to show the nonhomogeneity of some porcelain enamels.—BLR.

5.4.2, 3.5.9

Recent Ceramic Coatings for High-Temperature Alloys. *Ceramic Age,* 59, 29-30 (1952) Jan.

Various types of ceramic coatings developed by National Bureau of Standards and applications.—MR.

5.4.2, 3.5.9, 6.2.5, 8.9.1

Ceramics Investigation; The Effect of Ceramic Coated Alloys at Elevated Temperatures. WILSON G. HUBBELL. *Western*

You can't stop a flood with a sieve

You can't stop corrosion with ordinary paints ... it takes BITUMASTIC COATINGS!

CORROSION can't be stopped by ordinary paints or conventional protective coatings. They can't protect surfaces against the ravages of rust for any appreciable length of time.

But Bitumastic Coatings can!

FIRST—Unlike maintenance paints, Bitumastic® Protective Coatings are specially formulated from a coal-tar pitch base* that is, for all practical purposes, impervious to water. When you keep moisture away from an exposed surface, you *stop* corrosion.

SECOND—Bitumastic Coatings provide an extra-tough, extra-thick barrier against corrosive elements—a barrier that is impenetrable. These coatings provide up to 8 times the film thickness of conventional paint coatings.

**Hi-Heat Gray contains a vehicle with metallic pigment.*

THIRD—Bitumastic Coatings stop corrosion caused by moisture — acid fumes—alkaline fumes—salt air—heat.

There are 6 Koppers Coatings—formulated to control corrosion of metal and deterioration of concrete. Use the coupon for full information, or see our catalog in Sweet's Plant Engineering File.

SEND FOR SET OF FREE BOOKLETS!

Koppers Company, Inc., Tar Products Division
Dept. 404-T, Pittsburgh 19, Pa.

Please send me, without charge or obligation, complete information on corrosion prevention.

Name.....

Address.....

City.....Zone.....State.....

KOPPERS BITUMASTIC PROTECTIVE COATINGS
REG. U.S. PAT. OFF.

SOLD THROUGH INDUSTRIAL DISTRIBUTORS

KOPPERS COMPANY, INC., Tar Products Division, Dept. 404-T, Pittsburgh 19, Pa.

DISTRICT OFFICES: BOSTON, CHICAGO, LOS ANGELES, NEW YORK, PITTSBURGH, AND WOODWARD, ALA.

61a

Machinery and Steel World, **43,** 82-85 (1952) Jan.

A series of tests conducted with ceramic coated exhaust system components show that the ceramic provides the protection necessary to extend the life of 19-9 DL stainless steel at elevated temperatures encountered in aircraft service. Micrographs.—MR.

5.4.2, 7.1, 3.5.9

Ceramic Coatings. JOHN V. LONG. *Machine Design,* **24,** 122-126 (1952) May.

Discusses research and results on development of coatings for heat-resistant alloys for jet engines. Describes Solaramic process which provides engine designers with a new and unique series of ceramic coatings capable of enhancing metal life by reducing oxidation and intergranular corrosion and by stabilizing metal surfaces so they can operate for greatly extended periods at high temperatures. Shows service results of ceramic-coated SAE-1010 and 4130, and 321 stainless.—BTR.

5.4.3, 8.1.4, 7.2

Plastic Lining Protects Sewer. *Engineering News-Record,* **148,** No. 14, 74-75, (1952) April 3.

Purpose of the lining is to protect the concrete from deterioration as result of attack by hydrogen sulfide. Work involved in pipe on the Magnolia trunk sewer serving areas in California. Engineers on the job specified plastic-protected pipes for the larger sizes and either vitrified clay pipes or plastic-protected concrete pipe on the smaller sizes. The plastic material used is manufactured by Amercoat Corp. under the trade name Amer-Plate. Application of the plastic liner to the reinforced concrete pipe does not require any new procedures in the pipe manufacture.—INCO.

5.4.5

Silicone Coatings Protect Metals. C. E. ARNTZEN AND R. D. ROWLEY. *Materials and Methods,* **35,** No. 1, 82-84 (1952) Jan.

Silicone vehicles for baking enamels offer the possibility of securing high temperature and weather resistant flexible coatings not previously available. This article discusses the outstanding properties of the silicone finishes such as heat resistance, weathering and chemical resistance, and also the applications for which they are best suited. Tables offer more detailed information.—TDD.

5.4.5

"Vinylite" Resin VMCH for Coatings. Bakelite Company, A Division of Union Carbide and Carbon Corporation, 260 Madison Avenue, New York 16, N. Y. *Technical Release No. 12* (Nov. 1952) 16 pp. 8½ x 11 inches. Paper bound.

Describes the distinctive properties of VMCH Resin, which while essentially the same as Resin VYHH, contains about one percent of interpolymerized maleic acid. The carboxyl groups of this acid are credited with the unusual properties of the resin, which include high adhesion to clean metal surfaces and points of reactivition the resin molecular chains for cross-linking reactions. The 16-page and cover booklet describes the proper use and formulation of the new resin in surface coatings, with emphasis on the points of difference with older resins. Copies are available on request.

5.4.5

The How and Why of Protective Coatings. R. P. HILL. Chemical-Proof Construction, Inc. & Pulp Bleaching Co. Paper before Am. Pulp & Paper Mill Superintendents Assoc., 32nd Ann. Conv., Portland. *Paper Trade J.,* **134,** No. 14, 22, 24, 26 (1952) Apr. 4.

Discussion of protective coatings, both technical and maintenance. Review of coatings including rubber-natural and synthetic, the phenolics and the vinyls. —INCO.

5.4.5, 1.7.1, 2.5, 1.6

ASTM Standards on Paint, Varnish, Pacquer and Related Products. Sept. 1952. 6 x 9, paper bound, 781 pages plus xix. American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. Per Copy, $5.75.

The eighth edition of the compilation of ASTM standards on paint, varnish, lacquer and related products provides more than 200 specifications, tests and definitions issued by ASTM Committee D-1. Related standards from other committees are also included.

Material covered include specifications for pigments, drying oils, paint driers, thinners, shellac, varnish, naval stores, lacquer and lacquer materials, traffic paint, bituminous emulsions, paint tests, putty and paint weathering tests. Of the 23 new standards included, 16 are methods of test, six are specifications and one covers forms for reporting results of exposure tests on paint.—MR

5.4.5, 3.5.9, 8.4.3

Silicone Paint Protects High Temperature Refinery Equipment. M. LEAVENWORTH, Dow Chemical Corp. *Corrosion* (News Section), **8,** No. 2 (Topic of the Month, 1 (1952) Feb.

A new type of semi-organic paint formulated with silicone resin retains its original appearance longer than other paints. An important factor in the formulation of silicone paints is the heat stability and relative inactivity of available pigments. Finishes pigmented with aluminum powders, zinc dust, flaked stainless steel or powdered mica maintains stability at temperatures ranging up to 1000° F. Precautions in applying silicone finishes, spray application and the silicone molecule are discussed. These finishes are useful in the refineries of the petroleum industry. Photographs.—INCO.

5.4.5, 5.4.7, 5.9.2

Araldite Surface Coating for Light Metals. P. A. DUNN. *Light Metals* (England), **15,** No. 166, 38-40 (1952) Jan.

The pre-treatment of light alloys for painting can be facilitated by the use of Araldite coatings. A single coat of this lacquer can be applied after degreasing in a trichlorethylene vapor bath. It gives a hard, tough flexible coating, highly resistant to abrasion. The lacquers are thermosetting and based on an oil-free synthetic resin of the ethoxyline class. It may be applied by spraying, dipping or roller coating. Of these, dipping is the most successful. The lacquer is thinned to such a viscosity that the flow time through a Number 4 Ford Cup is 12 to 14 seconds. After dipping, the article should be stoved. Certain pieces which may be subject to extensive corrosion, may be dipped a second time in lacquer which has been pigmented with zinc chromate. The minimum temperature for stoving should be 320° F, and the time necessary depends on the properties required on the final film. These coatings exhibit resistance to a wide range of food and pharmaceutical products, and can be used to coat the inner surfaces of aluminum collapsible tubes. The coating is as flexible as the tube itself.—ALL.

5.4.5, 5.4.7, 5.9.2

The Properties of Araldite Lacquers. P. A. DUNN. *Light Metals* (England) 15, No. 169, 131-133 (1952) Apr.

The "Araldite" lacquer, based on an oil-free ethoxylene resin provides aluminum with an excellent corrosion resisting surface. The coating is applied in three stages-degreasing, dipping and stoving for one hour at 180° C. The chemical resistance of the film is directly related to the amount of stoving time allowed. The coatings have good resistance to many acids, soap and salt solutions, tap water, wines and brandy and industrial alcohol. However, only fair resistance was obtained for ethyl acetate, concentrated hydrochloric acid, formic acid, hydrofluoric acid and hydrogen peroxide. The lacquers also exhibit outstanding characteristics of adherence to the metal base. Araldite coatings are extremely flexible, and can be applied to metal sheets before forming. The Erichsen machine, used to test the flexibility of the coating, gave results as follows: with a stoving time of 20 minutes at 160° C, the Erichsen value was 0.5 (in mm.) and with a stoving time of 160 minutes and stoving temperature of 220° C the value was 9.3. When tested in shear, it was found that a load of 3,200 psi was needed to separate the coating from the base metal.—ALL.

5.4.5, 5.4.8

Butyl Titanate in Heat Resisting Aluminum Paints. A. HANCOCK. *J. Oil Colour Chemists' Assoc.* (England), **35,** No. 379, 28-39 (1952) Jan.

The physical and chemical properties of butyl titanate are fully described. Properly formulated butyl titanate/aluminum paints when applied to steel and burned off leave films of titanium dioxide and aluminum which are very adherent and withstand high temperatures for a long time. They show greater resistance to heat and corrosion than the films obtained by using ordinary aluminum heat-resisting paints of the non-silicone type. The following considerations should be taken into account in preparing butyl titanate/aluminum paints: a) the ratio of butyl titanate to aluminum should be 1:1 (giving a ratio of titanium dioxide to aluminum of approximately 0.25:1 in the final film); b) the amount of resin should be kept at a minimum. Butyl titanate/aluminum paints are best applied by spraying, but satisfactory results can be obtained by brushing. After application of the paints, an adequate air drying time should be given to allow the volatile solvents to be removed. (Author's summary.)—ALL.

5.4.5, 5.8.2

Metal Primer. *Chem. Eng.,* 59, No. 4, 208-209 (1952) Apr.

New Primer P-50 from Prufcoat Labs. is composed of a heavy-bodied oil-modified synthetic resin vehicle, carrying a high percentage of inhibitative pigments, principally zinc chromate. It is effective from an inhibitive standpoint on iron, steel, aluminum and magnesium. It also exhibits good adhesion to brass, copper, lead and Monel metal. Prufcoat Primer P-50 requires only over-night drying prior to the application of finish coat.—INCO.

5.4.5, 6.4.2

Some Further Observations on the Painting of Aluminum Alloys. W. A. EDWARDS, *Light Metals* (London), **15**, No. 167, 61-63 (1952) Feb.

A previous paper gave details of atmospheric exposure tests on a variety of protective coatings on aluminum and aluminum alloys and also the results of salt spray tests on 16 bare and varnished aluminum alloys and steel. The present paper gives the results of 50 months exposure to the atmosphere of the 16 bare aluminum alloys and steel and mentions the behavior of painted specimens after exposure to 1) the atmosphere, 2) the A.R.D. salt spray test and 3) the C.R.L. beaker test.—B.N.F.

5.4.5, 8.1.2, 6.1

Painting. Council for Codes of Practice for Buildings. Brit. Stand. Code of Practice CP231 (1952), 166 pp. Issued by British Standards Institution, 24 Victoria Street, London, S. W. 1. 10s.

Painting of all kinds of building materials, non-metallic and metallic, including sections on iron and steel (13 pp.) and non-ferrous metals (18 pp.) the latter covering aluminum, magnesium, zinc (and galvanized steel), cadmium-coated steel, copper, palladium, terne plate and tin. All aspects are discussed.—BNF.

5.5 Oil and Grease Coatings

5.5.2, 5.8.2

A Study of Rust Preventive Properties of Greases. R. J. BURGER, B. RUBIN, AND E. M. GLASS. *Lubrication Eng.*, **8**, 21-23, 26-27, 46 (1952) Feb.

A laboratory procedure using ball bearings which showed good correlation with service results. The investigation included petroleum, diester, Ucon oil, and silicone greases. Several factors influencing the degree of corrosion resistance were investigated. Effect of rust inhibition.—MR.

5.6 Packaging

5.6.2, 6.4.2, 1.2.4

Aluminum Foil Stops Corrosion. *Iron Age*, **169**, 147 (1952) May 1.

Method for sealing vehicles for storage and shipment to exclude water, developed and tested during the past four years at Letterkenny Ordnance Depot, Chambersburg, Pa. A bituminous mastic compound, aluminum foil, and an aluminum paint are used. The method has been adopted for use by the Ordnance Corps.—MR.

5.7 Treatment of Medium

5.7.8, 4.3.6, 5.8.2, 7.2

Polyphosphate Detergents in Mechanical Dishwashing. 1) Solubilizing Action of Polyphosphates on Certain Metals. 2) Metallic Staining of Silverware. L. R. BACON AND E. G. NUTTING, JR. *Ind. Eng. Chem.*, **44**, No. 1, 146-150, 150-155 (1952) Jan.

1) Solutions of 4 polyphosphates were shown to dissolve copper, zinc and brass; machine parts such as pumps, valves, etc, have completely failed after 6 months' use with commercial cleaners. Addition of sodium metasilicate reduces the attack, pyrophosphates being the most difficult to inhibit. 2) Copper dissolved by the process described in (1) will deposit on silverware in electrical contact

Even in Corrosive, Humid or Dirty atmospheres, you don't have to sandblast rusty steel before applying vinyls or other corrosion-resisting finishes. Rustbond Primer sticks to rusty steel *without peeling.*

Brush Rustbond Primer directly over steel which has been lightly wirebrushed. Then apply the top finish of your choice. Perfect compatibility! No intermediate coat necessary!

Rustbond Primer is not only a primer—but a good corrosion-resisting paint. Does not need to be immediately covered with top coat. Practically eliminates undercutting corrosion on steel when primer is exposed by skips or physical damage to top coat.

Besides rust-inhibiting pigments, Rustbond Primer contains a revolutionary new compound which *wets* and *acts* on rust—without forming water or oxygen. Rust accumulation slowly disappears—the bond to steel gradually *increases.*

Rustbond Primer gives excellent protection on edges—where most paints fail first. Top coat failures on sharp edges are practically eliminated.

A summary of rigid tests made of Rustbond Primer during two years' extensive field work is contained in Bulletin 150. Write for it today.

CARBOLINE COATINGS • CEMENTS • FINISHES

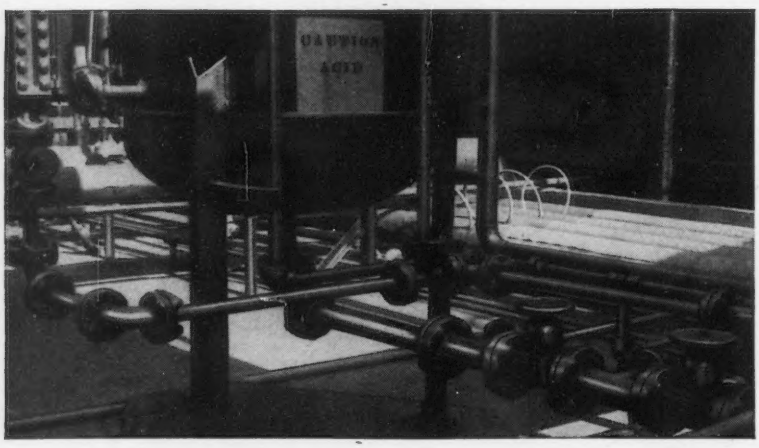
CARBOLINE COMPANY
333 Thornton Avenue St. Louis 19, Mo.

63a

DOW

CORROSIVE FERRIC CHLORIDE FLOWS THROUGH THIS SARAN LINED INSTALLATION

Large West Coast refinery depends on easy-to-install SARAN LINED STEEL PIPE to resist corrosion and assure uninterrupted processing



Some time ago, a large West Coast oil company investigated better methods to handle corrosive ferric chloride solution. The company's successful operation demands uninterrupted processing. Unscheduled "shut-downs" mean production pile-ups, lay-offs and heavy expense. Saran Lined Steel Pipe was successful from the start. The use of Saran Lined Pipe Fittings and Valves assured tight, leak-proof joints. The dependable, long-term service and excellent corrosion resistance of strong, rigid Saran Lined Pipe will postpone replacements indefinitely. Saran Lined Steel Pipe can be delivered immediately, cut and threaded to your specifications or fabricated in the field with your own equipment. We'll be glad to assist you with installation plans. Write or call the SARAN LINED PIPE COMPANY, Ferndale, Michigan. Offices in New York • Boston • Pittsburgh • Tulsa Philadelphia • Chicago • Portland Indianapolis • San Francisco • Houston Denver • Los Angeles • Seattle Cleveland • Charleston, S. C. Toronto • Montreal.

Saran Lined Pipe Company
2415 Burdette Ave., Ferndale, Mich.

Please send me a copy of your catalog on Saran Lined Pipe, Valves and Fittings.

Name_____

Title_____

Company_____

Address_____

City_____ State_____

RELATED SARAN PRODUCTS
Saran rubber tank lining • Saran rubber molding stock • Saran pipe and fittings • Saran tubing and fittings

you can depend on DOW PLASTICS

DOW

64a

with a more electronegative metal (e.g., aluminum or zinc) thus causing a brassy or dark-colored tarnish.—BNF.

5.8 Inhibitors and Passivators

5.8.2, 3.6.5

Inhibitors and Promoters of Corrosion in Liquid Media. (In French.) L. CAVALLARO AND A. INDELLI. *Rev. met.*, **49**, No. 2, 117-124 (1952) Feb.

Reviews authors' work on effects of chromates and nitrites on corrosion of steel, and of those and other substances (potassium chlorate, sodium sulfite and organic compounds) on galvanic corrosion of iron/zinc and iron/copper couples. The corrosion of steel in sulphuric acid solutions containing sulfur dioxide, ammonia, hydrogen sulfide and hydrogen peroxide was studied and the inhibitive effect of orthotolyl thiourea in such solution investigated. The results are considered from the point of view of the effect of the various substances in the anodic and cathodic reactions of the local cells on the steel.—BNF.

5.8.2, 2.3.4, 6.4.2

Protection of Aluminum and its Alloys Against Corrosion by Treatment with Acid Aqueous Solution. HIKOZO ENDO AND HIDEO SUGAWARA. *J. Japan Inst. Metals*, **16**, No. 3, 153-157 (1952) Mar.

Specimens of aluminum, duralumin, super-duralumin, silumin, Lautal and KS-Seewasser were pretreated at room temperature for 10-15 minutes with various acidic solutions of chloride, sulphate, nitrate, phosphate, etc., containing sodium silicate, zinc carbonate, sodium silicofluoride, etc.

Corrosion resistibilities of protective films prepared by the above mentioned process were compared in 3% sodium chloride solution containing zinc carbonate and sodium silicofluoride which proved to be the better inhibitor.—JSPS.

5.8.2, 4.4.5, 8.3.1

The Inhibition of Sodium Trichloroacetate Weed Killer Solutions. F. N. ALQUIST AND J. L. WASCO. A paper presented at the Eighth Annual Conference, National Association of Corrosion Engineers, Galveston, Texas, March 10-14, 1952. *Corrosion*, **8**, No. 12, 410-412 (1952) Dec.

The addition of small amounts of sodium dichromate to sodium trichloroacetate inhibits the corrosiveness of subsequent solutions on various metals. The presence of an oil layer at the air-liquid interphase prevents much of the liquid-level corrosion.

5.8.2, 5.9.2, 1.6

Efficient Pickling with "Rodine." American Chemical Paint Company, Ambler, Pennsylvania. *Bulletin*, No. 13, 1952 80 pp. 6 x 9 inches. Paper bound.

Described in detail the uses of Rodine inhibitors in pickling applications. The booklet includes a comprehensive index and a large volume of practical data and experimental results pertaining to the use of these inhibitors. Copies are available on request from the company.

5.8.2, 6.6.4, 6.4.2

New Interleaving Paper for Aluminum Inhibits Water Stain. W. Y. BLEAKLEY AND C. C. LACY. *Materials and Methods*, **35**, No. 2, 176, 178, 180 (1952) Feb.

Water staining does not affect the physical properties of aluminum sheet, but does mar the surface of finished sheet products. By using impregnated paper sheets, which are placed between

PROTECTION AGAINST CORROSION

KONTOL PROTECTS SUCKER RODS, TUBING, CASING, GATHERING LINES, PRODUCTS LINES AND TANKAGE

Kontol is an organic corrosion preventive which affords protection by forming a tough protective film over metal surfaces. Its protective influence is persistent and continuing, so that its benefits are noted in surface, as well as in the sub-surface, equipment.

Kontol protects against the various forms of corrosive attack, including hydrogen embrittlement and hydrogen blistering. Useful in protecting all types of primary production equipment, it also has been found useful in secondary recovery water-flooding, where its bactericidal properties are an added advantage. In addition to these usages, Kontol has also proved effective in preventing corrosion in natural gasoline plants.

For complete information, ask your Tretolite field engineer, or write to:

VISIT OUR EXHIBIT
I.P.E.-TULSA
MAY 14-23
Petrolite Building

TRETOLITE COMPANY

Chemicals and services for the petroleum industry

SAINT LOUIS 19, MISSOURI • LOS ANGELES 22, CALIFORNIA

DEHYDRATING • DESALTING • CORROSION INHIBITING • SCALE PREVENTING
PARAFFIN REMOVING • WATER DE-OILING

the aluminum, for surface protection as a carrier for chemical compounds which have shown corrosion inhibiting qualities, the Kaiser Aluminum Company is preventing this staining. Two alloys have thus far been investigated—3S and 24S. Sodium chromate in the range of 1.5 to 3 percent, based on the dry weight of the treated paper, was found to be sufficient.—ALL.

5.8.2, 8.1.1, 8.1.3

Use of Chromates for Inhibiting Corrosion. G. T. COLEGATE. *Ind. Heating Engr.*, **12**, 223-225, 270-271, 302-302 (1950); *J. Iron & Steel Inst.*, **168**, Part II, 206 (1951).

The advantages of using corrosion-inhibitors and the relative merits of chromates and dichromates are discussed. Recommendations are made on the use of chromates in evaporation and other industrial coolers, air-conditioning systems, refrigerator equipment, heating systems, etc. The effect of chromates on the skin is considered.—RPI.

5.8.3

Inorganic Corrosion Inhibitors in Acid Solution. CECIL V. KING, EMIL GOLDSCHMIDT AND NATALIE MAYER. New York Univerity. April 15, 1952. 12 pp. (NYO-3462).

In dilute hydrochloric acid with excess potassium nitrate as a depolarizer, iron, zinc, and cadmium dissolve at, or nearly at, a maximum rate controlled by the rate of convection and the speed of diffusion of the hydrogen ion. The dissolution rates of these metals may be reduced to comparatively small values by addition of dichromate, molybdate, or tungstate. With very pure iron and zinc the dissolution rate in the presence of dichromate can be reduced still more by the addition of a soluble fluoride. While none of the solutions used are highly protective, the experiments described are of aid in interpreting the mechanism of inhibition. (Author.)—NSA.

6. MATERIALS OF CONSTRUCTION

6.3 Non-Ferrous Metals and Alloys—Heavy.

6.3.6, 3.4.6, 3.5.9, 3.7.4

Low Temperature Oxidation of Copper. II. Reaction Rate Anisotropy. T. N. RHODIN, JR. *J. Am. Chem. Soc.*, **73**, 3143-3146 (1951) July.

The oxidation rate of single-crystal copper surfaces exposed to pure oxygen at temperatures from 78° to 323° K. was observed to be highest for the least densely packed (100) face and smallest for the most densely packed (111) face. The rate anisotropy is adequately described by the mathematical treatment of Mott and Cabrera, although the physical significance of their assumptions is ambiguous. The reaction-rate anisotropy was also shown to be consistent with the theoretical requirements of Frand and Van der Merwe for the existence of oriented overgrowths. 22 references.—BLR.

6.3.8, 8.8.3

The Use of Lead in the Plating Room. *Plating*, **88**, 39, 57 (1951) Jan.

Discusses corrosion resistance and formability, lead-base alloys and applications of lead equipment in plating, electropolishing and anodizing.—BNF.

6.3.11, 4.3.6, 3.4.6

The Corrosion of Silver by Potassium Cyanide Solutions and Oxygen. (In English.) VIBEKE LUND. *Acta Chem. Scand.*, **5**, No. 4, 555-567 (1951).

Presents results of experimental study of mechanisms and kinetics of above reaction. The reaction is of principal importance in recovery of silver by cyanidization.—BLR.

6.4 Non-Ferrous Metals and Alloys—Light

6.4.4

Notes on Magnesium Alloys.—I.-II. F. A. FOX. *Engineer*, **191**, No. 4958, 148-150; No. 4959, 180-182 (1951) Feb. 2, 9.

A general article, outlining the manufacture, properties, and uses of magnesium base alloys. The various processes for the extraction of magnesium are briefly described, with an account of the properties of the commercial alloys in the cast, wrought, extruded, and forged conditions. The effect of particular alloying elements—zirconium, aluminum, manganese, cerium, etc.—on the physical and mechanical properties of the alloys are discussed and the tensile properties of the common Elektron alloys are tabulated. Heat-treatment of aluminum- and zirconium-containing alloys is discussed and the fatigue properties as indicated by the Wohler and Haigh tests and their relation to static properties, are dealt with in some detail. The author concludes with sections on surface protection and industrial application of magnesium alloys.—MA.

6.4.4, 3.4.8

The Effect of Phosphorus on the Corrosion-Resistance of Magnesium and some of its Alloys. E. F. EMLEY, A. C. JESSUP AND W. F. HIGGINS. *J. Inst. Metals*, **80**, No. 1, 23-32 (1951) Sept.

From immersion tests in 3% sodium chloride saturated with magnesium hydroxide, it is concluded that corrosion resistance of pure magnesium is reduced by the presence of over 0.002% phosphorus, but that this effect can be suppressed by addition of manganese though not if normal iron content is present. Phosphorus also has bad effect on corrosion resistance of high purity Elektron A8 (8% aluminum, 0.4% zinc, 0.25% manganese). Phosphorus is precipitated from magnesium by zirconium.—BNF.

6.4.4, 4.3.3, 3.6.5

Effects of Alkaline Detergents on a Magnesium Die Casting Alloy. J. FRED HAZEL AND WILLIAM STERICKER. *J. Electrochemical Society*, **98**, 273-276 (1951) July.

Test panels of AZ91 alloy were immersed in still and electrolytic baths of alkaline electrolytes at 90° C. Weight changes and appearance of the treated panels were noted. The metal was not attacked by sodium hydroxide, sodium orthophosphate, and the more alkaline silicates, except when it was the anode. The Ma-ion sequesterers, tetrasodium pyrophosphate, Calgon and Quadrafos caused marked weight losses. Attack of the metal occurred in all cases where it was used in the anode. 13 references.—MR.

6.4.4, 5.4.5

A New Primer for Magnesium. *Modern Metals* (U.S.A.), **7**, No. 5, 53-54 (1951) June.

Efforts towards developing a coating or primer which would protect magnesium against atmospheric attack have met with some success. Grand Rapids Varnish Corporation have developed such a primer—the 66-4005. The corrosion inhibitor is a synthetic zinc chromate primer similar in appearance and performance characteristics to the well-known Navy type. When used as a wash coat primer and followed by suitable air drying or baking top-coats, it has shown exterior durability, salt spray resistance, and moisture resistance considerably superior to the standard specification types.—ALL.

6.4.4, 5.4.5

Impregnating Magnesium Castings. *Modern Metals* (U.S.A.), **7**, No. 6, 37-38 (1951) July.

Impregnation of magnesium, aluminum, bronze and other nonferrous castings is done with a styrene-linseed copolymer. This new substance, known as Armetol, is a ready-mixed colorless plastic material composed of monomeric styrene and specially processed linseed oil. When polymerized within the pores of a casting it resists attack by hot oil, gasoline, boiling water, heat and chemical treatment. It effectively seals microporosity due to shrinkage, gas holes, etc., and its low viscosity gives excellent penetration even at low temperatures. It is non-electrolytic and does not corrode or change the original characteristics of the metal. It is not broken by expansion or contraction or operating stresses. Armetol is used in conjunction with a catalyst which controls the rate of solidification of the material when the impregnated casting is baked. This is usually tertiary butyl hydroperoxide. The impregnating procedure is similar to that for tung oil. After preparatory treatment the castings are rinsed, dried and placed in the impregnator. A vacuum of 28 inches mercury is applied for 20 to 30 minutes before the impregnating solution is pumped in to cover the castings. The vacuum is released and a pressure of 70 to 90 psi applied for 20 to 30 minutes. An oil bath polymerizes the Armetol, converting it into a tough plastic material that effectively and permanently seals microporosity. It is possible to impregnate castings individually also. Armetol is inflammable and should be handled accordingly.—ALL.

7. EQUIPMENT

7.1 Engines, Bearings, and Turbines

7.1, 6.2.1, 3.7.3

High-Temperature Steels and Alloys for Gas Turbines. T. BISHOP. *Metal Progress*, **59**, No. 5, 653-656, 690-696 (1951) May.

A symposium on high-temperature steels and alloys for gas turbines was held in London on 21-22 Feb., when some 40 technical papers were presented by members of the Institute and discussed by Britishers and their guests from all over the world. The papers presented fall into six groups and are reviewed in this article: (1) User's point of view, including three papers by firms engaged in the construction of gas turbines. (2) Nickel-base alloys, and austenitic and ferritic steels now being produced in Britain. (3) Six papers on the properties of high-temperature fatigue, and variation in elastic modulus. (4) Seven papers on manufacturing techniques, such as centrifugal casting, precision casting, welding, and machining. (5) Research techniques. (6) General developments in sintered metal and ceram-

ics. A rapporteur gave a resume of each group of papers, whereupon a general discussion occurred before attention was given to the subsequent group.—TDD.

7.1, 8.9.2

The Corrosive Properties of Automobile Transmission Oils. (In German.) A. BUKOWIECKI. *Schweiz. Arch. angew. Wiss. u. Tech.*, 17, 182-191 (1951) June.

Nine samples of above oils with and without chlorine were tested for corrosive action on iron and copper. Oils heated to 80-120° C. were found to have little effect on iron even after extended contact, except that chlorinated oil showed distinct "after-rusting" effect on iron, i.e., iron removed from oil had an increased tendency to rust when stored in humid atmosphere. All 9 oils strongly attacked copper at 122° C. Includes graphs, photographs, and tabulated data. 28 references.—BLR.

7.1, 6.2.5, 3.5.9

Scaling of Gas-Turbine Alloys. A. PREECE. Univ. of Durham. Paper before Iron & Steel Institute, London, Feb. 21-22, 1951. Symposium on High-Temperature Steels and Alloys for Gas Turbines, Feb., 1951, 149-152. *Metallurgia*, 43, No. 258, 166-169, 185-189 (1951) Apr. *Metal Progress*, **59**, No. 5, 653-656+ (1951) May.

The effect of scaling is discussed. It is not possible to predict the effect of particular operating conditions on particular alloys, as for instance the oxidation of alloys containing more than four percent molybdenum at temperatures above 800° C, or the considerable effect of small amounts of cerium or thorium in the nickel-chromium alloys. Sulfur and vanadium penta-oxide attack the oxide film and cause corrosion at the metal scale interface. Chart gives the oxidation rate of 25 percent chromium, 18 percent nickel steel in the presence of a fuel with a 0.2 percent sulfur dioxide content. 24 references.—INCO.

7.2 Valves, Pipes and Meters

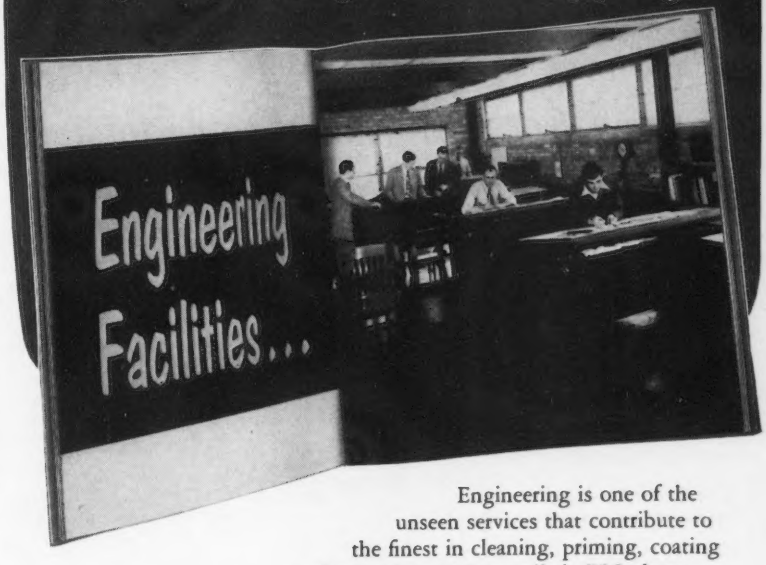
7.2, 6.2.5, 2.2.3, 3.5.9

Some Experience in Service (Power, Oil and Chemical Plants). J. J. B. RUTHERFORD, Babcock & Wilcox Tube Co. Paper before ASM, 32nd Nat'l Metal Congress & Exposition, Chicago, Oct. 23-27, 1950. ASM, High Temperature Properties of Metals, 1951, 113-170.

The uses and failures of various types of steel tubing used at the elevated temperatures in petroleum refining processes are described. Length of service and operating conditions for the various pipes is discussed. 18-8 stainless steel oil pipe operating at 950° F at 800 psi gave satisfactory service for 8 years. It showed intergranular corrosion, but gave no evidence of corrosion in service and the mechanical properties were unimpaired. 18-8 stainless steel tubes in service as a sour naphtha superheater for a butadiene plant at 1400° F show a pronounced pitting. Stainless 25-20 tubes in a crude sulfur boiler, suffered intergranular corrosion from the salts present. A tube hanger in an oil heating furnace made of 25-12 steel casting gave excellent service until a change in the heating oil precipitated vanadium pentaoxide on the surface at 1400° F and then the steel rapidly deteriorated. The changes in the steel and carbide precipitation at the elevated temperatures is discussed.—INCO.

Behind the Scenes at **PLS...**

It's the Services You Don't See that Make the Difference in the Quality of Pipe Coating and Wrapping



Engineering is one of the unseen services that contribute to the finest in cleaning, priming, coating and wrapping service at all six PLS plants. Experienced engineers combine their skills to design advanced equipment, used exclusively by PLS specialists. Significant advancements include large drying ovens, grit cleaning machines, thermostatically controlled melting kettles, and other special equipment designed and built by PLS to assure dependable protection every step of the way.

PIPE LINE SERVICE PLS **CORPORATION**

Pioneers in Steel Pipe Protection
General Office and Plant: Franklin Park, Illinois

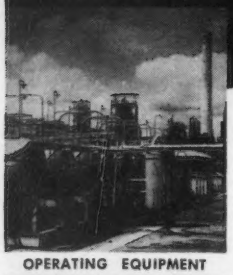
Plants at Glenwillard, Penna.; Longview, Texas; Corpus Christi, Texas; Harvey, Louisiana; and Sparrows Point, Maryland

DEPENDABLE SERVICE SINCE 1931

67a

QUALITY SERVICE

THE SYMBOL OF HIGHEST PROTECTIVE POWER AGAINST CORROSION!



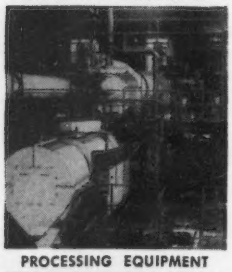
OPERATING EQUIPMENT

ARco RUBBER COVERINGS ...formulated to do the job!

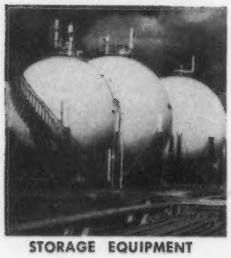
● From 10 gallon drums to large storage tanks . . . from pipes and fittings to expansive exhaust systems . . . ARco rubber coverings protect this equipment and produce money-saving results everywhere in the chemical industry.

ARco Engineers will design, fabricate, insulate and erect complete ventilating, storage and processing installations . . . or, they will cooperate with your equipment manufacturer in making your systems corrosion-proof.

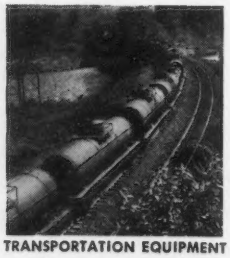
Whatever your requirements may be, ARco rubber coverings can help you reduce maintenance costs and increase production.



PROCESSING EQUIPMENT



STORAGE EQUIPMENT



TRANSPORTATION EQUIPMENT

Write for this valuable literature today. Get this important information on the values and services offered by ARco rubber linings to the chemical field.

ARco RUBBER PROCESSORS
DIVISION OF AUTOMOTIVE RUBBER CO., INC.
4033 Homestead Road • Houston, Texas
LICENSED APPLICATORS OF AMERCOAT PROTECTIVE COATINGS
MANUFACTURERS • DESIGNERS • ENGINEERS

ANYTHING CAN BE COVERED WITH RUBBER — BY ARco

7.2, 3.7.3, 3.5.7, 3.5.9

Welding High Pressure Steam Piping. N. L. NAVARRE. *Welding J.*, **30**, 1s-9s (1951) Jan.

This paper presents the development of welding procedures developed at the Welding and Electrical Laboratory of the United States Naval Engineering Experiment Station. Welding procedures for the following alloy steel tubing wherein each alloy is welded to itself were developed:

(a) ½ percent chromium-½ percent molybdenum
(b) 1 percent chromium-½ percent molybdenum
(c) 2¼ percent chromium-1 percent molybdenum
(d) 4-6 percent chromium-½ percent molybdenum
(e) 18 percent chromium-8 percent nickel plus niobium

Tests of composite joints between 2¼ percent chromium-1 percent molybdenum and 18 percent chromium-8 percent nickel steels wherein thermal shock is employed indicate that 19 percent chromium-9 percent nickel niobium weld metal is apparently more suitable for the purposes intended than 25 percent chromium-20 percent nickel. However, final conclusions concerning the suitability of these composite joints for use in high-pressure, high-temperature steam systems wherein the frequency and magnitude of thermal shock conditions are of prime importance, are being held in abeyance pending completion of considerably more research work in connection with this problem.—TIME.

8. INDUSTRIES

8.1 Group 1

8.1.4, 4.6.6

Removal of Iron from Water. P. H. BOUTHILLIER. *Munic. Utils*, **89**, No. 1, 28 (1951) Jan.

In many manufacturing processes, allowable concentration of iron in water much less than 0.3 ppm. permitted by U.S.P.H.S. standards. Theoretical considerations governing solubility of iron discussed and computed solubility of Fe^{++} and Fe^{+++} at pH values 3-9 tabulated. Sodium exchange zeolites will remove 3-4 ppm. Fe^{++} without injury to zeolite. Fe^{+++} coats zeolite and reduces its life and efficiency. Most common method of removal aeration and filtration, solubility of Fe^{++} being much less than of Fe^{+++}. Solubility decreases with increasing pH, hence carbon dioxide removal or addition of lime reduces solubility. Mathmatical equations for oxygen intake and carbon dioxide removal through aeration given. Oxygen required for oxidation of iron very small, 0.14 parts per ppm. Iron: reaction very rapid: 50 percent saturation with oxygen adequate for iron removal. Precipitation hastened by contact with previously oxidized material: submerged contact beds most efficient. Coke commonly used: aging period required. Settling period of little value unless iron concentration is 20 ppm. or more. Final step, filtration through sand: coarse sand (effective size 1.5 mm., uniformity coefficient 1) satisfactory if for iron removal only, but expansion during backwash difficult unless air-water wash used. Calgon prevents iron precipitation. Iron contamination due to corrosion of pipes controllable by lime addition to point of saturation with respect to calcium carbonate.—AWWA.

8.1.2, 6.2.5

Case Histories of Stainless Roofs. R. E. PARET. *Sheet Metal Worker,* **42,** No. 11, 35-36 (1951) Aug.

The installation of stainless steel roofs on St. Peter's Church, Albany; the Chrysler Building, NYC; Lake Court House, Gary, Indiana; and the John Hancock Insurance Co. building, Boston are described. The roofs are of batten-type construction or are spot welded.—INCO.

8.5 Group 5

8.5.3, 6.2.5

Ammonium Bisulphite Pulping—Its Application and Future in Sulphite Pulp Manufacture. R. M. JONES AND T. DEICHER. Barrett Div. Allied Chem. & Dye Corp. Paper, Am. Pulp & Paper Mill Superintendents Assoc., Northwestern Div., Spring Mtg., Minneapolis. *Paper Trade J.,* 133, No. 5, 20+ (1951) Aug. 3.

Outlines the basic technology of the application of ammonium bisulphite pulping and its future possibilities. When converting to ammonia base pulping in any mill, the corrosion properties of ammonia base acid must be considered. It is best to replace bronze with alloy steel in such equipment as acid pumps, steam nozzles, tower, tank and digester insert fittings and strainers. Experience with the grades of stainless steels used in most mills indicated that stainless piping, valves or fittings in sound condition will give satisfactory service with the ammonia base acid, but where pitting is extensive, serious leakage may occur. Tables are included.—INCO.

8.5.3, 7.6.6, 3.7.3

Corrosion of Mild Steel and Mild Steel Welds in Sulphate Digesters. R. A. HUSEBY AND M. A. SCHEIL. Paper before Tappi Symposium on Digester Construction and Operation, Ann. Mtg., New York City, Feb. 21, 1951. *Tappi,* **34,** 202-209 (1951) May.

Relative corrosion resistance of modern semi-killed and fully killed steels; corrosion resistance as related to exact chemical analyses; the effect of surface finish; comparative tests on several mild steel welds—manual and submerged arc; corrosion resistance of several low-alloy, high-tensile steels; data on the galvanic effect obtained by coupling mild steel to several stainless steels and effects of various heat treatments.—MR.

8.8 Group 8

8.8.6, 6.2.5

Bacitracin—Product of Biochemical Engineering. G. C. INSKEEP, R. E. BENNETT, J. F. DUDLEY AND M. W. SHEPARD. *Ind. and Eng. Chem.,* **43,** No. 7, 1488-1498 (1951) July.

The growth of the antibiotic bacitracin and its recovery from fermented beer are carried out in Type 304 stainless steel vessels. The vacuum concentrator containing butanol and bacitracin are glass-lined C Steel.—INCO.

8.9 Group 9

8.9.1, 6.4.1, 1.2.4, 5.9.2

Surface Protection of the Cutlass. *Modern Metals,* **7,** No. 6, 39-42 (1951) July.

The materials used in construction of the Navy's F7U Cutlass, the fastest jet in production, include Alclad 24ST aluminum, Metalite, a high aluminum-balsa wood sandwich material used in large skin areas, stainless steel sheathing in the after burner section and magnesium in the wheels. Paint adhesion and corrosion resistance on aluminum is obtained with the coating chemical Alodine. The coating insures a perfect bond for the paint system and lengthens its life. Alodine forms an amorphous phosphate film which is thin, tough, durable, non-metallic, continuous with and an integral part of the metal. The film allows paint bonding equal or superior to anodizing and possesses salt spray resistance equal or superior to that of chromic acid anodizing and abrasion resistance about 90 percent of that produced by anodizing. In addition, the film is flexible enough to withstand moderate draws, shows good resistance to galvanic corrosion, has high dielectrical resistance and is insoluble in water, alcohol, solvents and most dilute acids and alkalis. The coating ranges in thickness from 0.01-0.08 mil, is nontoxic and is unimpaired by temperatures that melt aluminum. Alodine can be applied by either spraying, immersion, tumbling barrel, flow coat or brush. The entire container equipment can be constructed of mild steel but the Alodine tank should be of stainless.—INCO.

8.9.3, 4.5.1, 3.6.1

Vigilance Underground—A Summary of Progress on Preventing Electrochemical Corrosion on Buried Pipe Lines. BRYAN PATTERSON. Presented at a Western Regional Meeting, National Association of Corrosion Engineers, Los Angeles, Cal., November 9, 1951. *Corrosion,* **8,** No. 7, 241-246 (1952) July.

The need for control of corrosion on underground metal is explained and elements of planning electrochemical control outlined. Principles of weighing dielectric control with economics are given and limitations and sequence of recommended dielectric tests are listed.

A survey of common specifications and inspection fundamentals is followed by recommendations concerning electronic inspection after lines are in service.

8.9.3, 5.1

Fighting Corrosion. MARSHALL E. PARKER. *Industry and Power,* **61,** 97-99 (1951) July.

Procedures recommended for protection of pipelines and other buried structures.—MR.

8.9.4, 1.7.1

Fatigue Tests of Rail Webs. R. S. JENSEN. *Amer. Railway Eng. Assoc. Bull.,* **51,** 640-647 (1950) Feb.; *ibid.,* **52,** 680-690 (1951) Feb. Parts I and II.

Part I consists of Appendix 11-b to Report of AREA Committee 4 on Rail. Presents laboratory test data and their evaluation as a part of a continuing research program on the above. Includes corrosion-fatigue data in tap water of two types.

Part II—Part of "Report on Assignment 11; Recent Developments Affecting Rail Section," from Report of Committee 4 on Rail. Results of laboratory corrosion fatigue tests in tap water are reported. Includes tables, graphs, and specimen photographs.

8.9.4, 4.6.6, 6.2.3

Cleaning Can Increase Corrosion on Passenger Cars. A. M. JOHNSON. Pullman Co. Paper before Railroad Corrosion Conf. (Inco), Wrightsville Beach, N. C., May 1-3, 1951. *Ry. Age,* **130,** No. 25, 62-63 (1951) June 25.

Acid-type cleaners are used on the exterior of railroad cars. The cars are washed every 1-3 days and the water and detergent seep into the insulation. The wet insulation stimulates corrosion of the steel surface. The soap solutions for mechanical scrubbers and recommendations for corrosion inspection are given.—INCO.

8.9.4, 5.11, 1.2.2

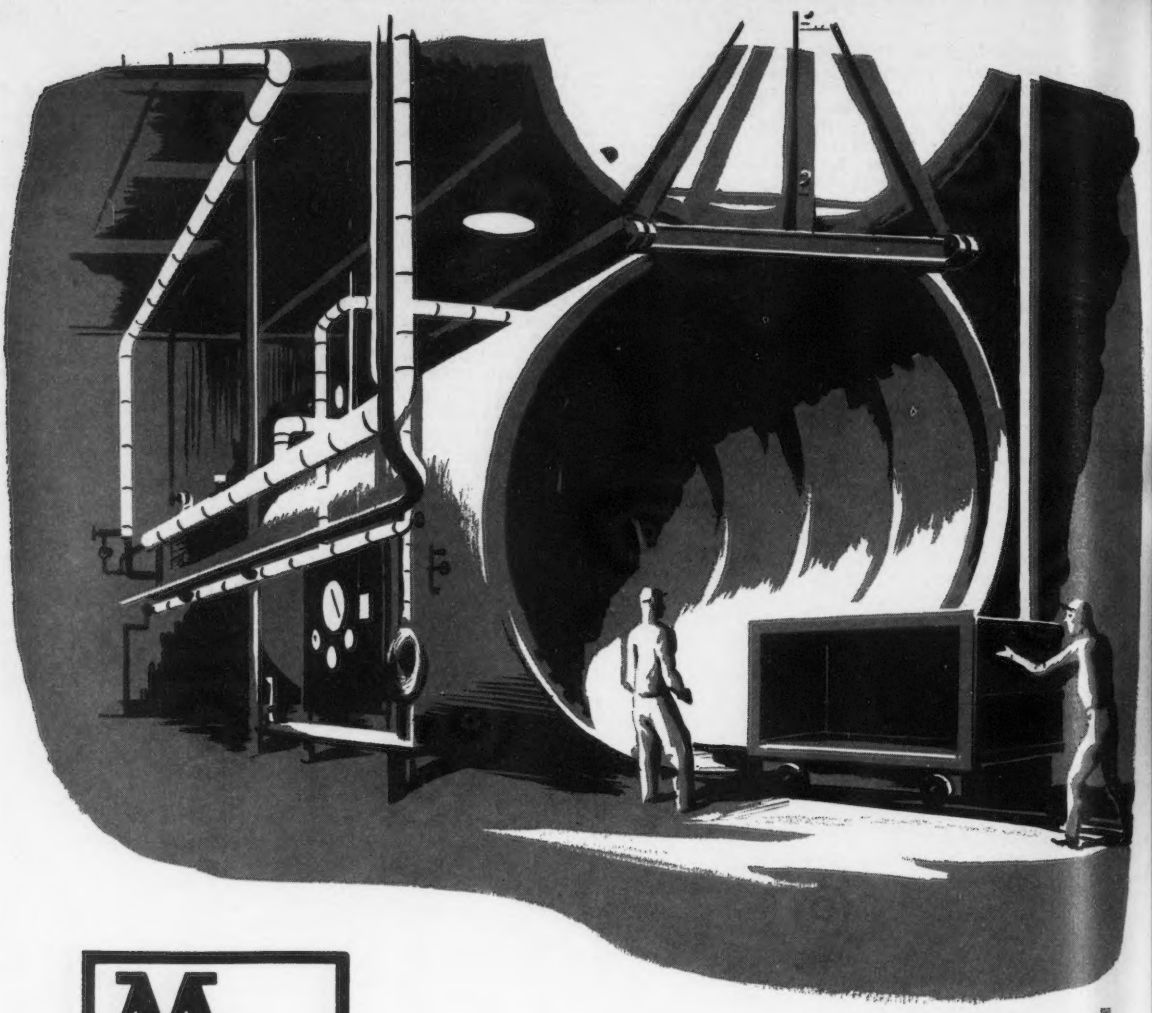
Corrosion of Cars Costs $191 Million a Year—How Can It Be Reduced? *Railway Age,* **131,** 65-69 (1951) Aug. 6.

Discusses typical kinds of corrosion in railway equipment and proposes techniques in design as a means of reducing corrosion damage.—BLR.

INDEX TO ADVERTISERS

Vol. 9 APRIL, 1953 No. 4

Alloy Steel Products Co., Inc. i
Amercoat Corporation ..... Inside Front Cover
American Chemical Paint Co. 15
Arco Rubber Processors Division Automotive Rubber Co., Inc. 52
Bechtel Corp. & H. C. Price Co. 17
Brance-Krachy Co., Inc. vii
Calgon, Incorporated 19
Carboline Company 47
Carpenter Alloy Tube Div. 21
Cathodic Protection Service 24
Chemical Corporation 6
Coast Paint & Lacquer Co. 27
Cooper Alloy Foundry, Inc. ix
Corrosion Directory 22, 23
Dampney Company, The 31
Dow Chemical Company ii
Dresser Industries, Inc. 37
Duriron Co., Inc. ..... Inside Back Cover
Eastman Chemical Products, Inc. 7
Federated Metals, Div. American Smelitng & Ref. Co. 3
Harper, H. N. Co. 16
Haynes Stellite Company, Division Union Carbide & Carbon Corp. 39
Hercules Powder Company 35
International Nickel Co., Inc. ..... xii, 13
Johns-Manville Sales Corp. 9
Koppers Company 150, 45
Mayes Bros., Inc. 20
Metalweld, Inc. 54
Michigan Pipe Company 26
Miller, Ray, Inc. 4
Monsanto Chemical Co. x
Mutual Chemical Company of America 10
National Carbon Company, Union Carbide & Carbon Corp. xi
Nicolet Industries, Inc. 12
Pipe Line Service Corporation 51
Pittsburgh Coke & Chemical Co. xiii
Plastic Engineering & Sales Corp. 28
Positions Available & Wanted 23
Richardson-Allen Corp. 30
Royston Laboratories, Inc. 32
Saran Lined Pipe Company 41, 48
Service Engineers, Inc. 29
Stearns, D. E. Company ..... Back Cover
Tapecoat Company, The 11
Tretolite Company 49
Tube-Kote, Inc. 36
United States Stoneware Company vi
Wilkinson Products Company 38
Williamson, T. D., Inc. 43
Wright Chemical Corp. 5



MW

Long experience
in the field of

RUBBER LINING*

for high resistance protection
against acids, corrosives and abrasives
makes MW
your logical choice
whatever your corrosion problem.
Our new Scotts Lane Plant
features the most modern vulcanizing equipment
for bonding rubber to metal.

☛ Write for the new MW Corrosion Protection Booklet

*Exclusive applicators for B. F. GOODRICH RUBBER • KOROSEAL • HYCAR • NEOPRENE

PROTECTIVE COATINGS DIVISION

METALWELD, INC.

SCOTTS LANE & ABBOTTSFORD AVE., PHILADELPHIA, PENNA.

70a

How much better will Durcopumps do your pumping job?

The Series R Durcopumps are engineered and built for heavy duty pumping with less maintenance. They're available as standard items in 12 alloys from our own foundry.

In many plants they're considered "standard equipment." *How much better* will they handle the corrosive you use?

Why not let us send you Durcopump Bulletin P/1? It will give you complete construction details and performance information to help you decide.

A DURCO representative near you will be happy to help you select the right pump in the right alloy.

RITE OR PHONE FOR YOUR FREE COPY OF BULLETIN

Series R Durcopumps

P/1

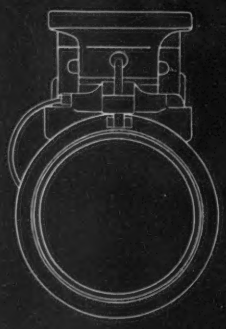
Duriron, Durichlor,
Durimet 20, Durco D-10M,
Chlorimet 2, Chlorimet 3, Monel, Nickel,
Inconel, Ni-Resist #2, 18-8-S-Mo, Cast Steel and Cast Iron

Sectional Index

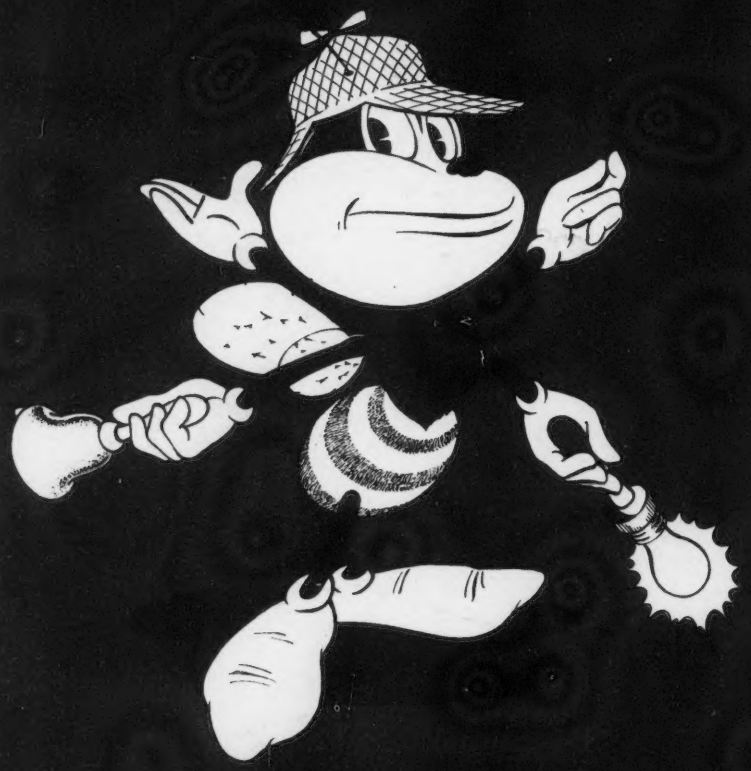
1 General Information
2 Machinable Alloy
3 Duriron-Durichlor
4 Wet End Interchangeability
5 Pump Selector Table
6 Packing and Lubricant

The Duriron Company, Inc.
Dayton 1, Ohio

DURCO
CORROSION RESISTING ALLOYS & EQUIPMENT



YES! WE'RE PLENTY PROUD



of our ability to detect pipeline holidays . . .

proud,

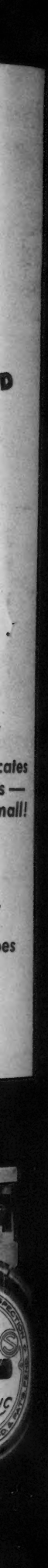
because . . . the Stearns Detector locates all holidays — large or small!

proud,

because . . . the Stearns Detector does not injure protective coatings

BETTER COATINGS CONSERVE STEEL

The D. E. STEARNS Co.

P. O. BOX 1234 SHREVEPORT, LOUISIANA

IN OUR TWELFTH YEAR